THE TENNESSEE VALLEY AUTHORITY'S KINGSTON ASH SLIDE: EVALUATION OF POTENTIAL CAUSES AND UPDATES ON CLEANUP EFFORTS

(111–54)

HEARING

BEFORE THE

SUBCOMMITTEE ON
WATER RESOURCES AND ENVIRONMENT

OF THE

COMMITTEE ON
TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

JULY 28, 2009

Printed for the use of the
Committee on Transportation and Infrastructure

U.S. GOVERNMENT PRINTING OFFICE

51–348 PDF WASHINGTON : 2009

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July 27, 2009

SUMMARY OF SUBJECT MATTER

TO: Members of the Subcommittee on Water Resources and Environment

FROM: Subcommittee on Water Resources and Environment Staff

SUBJECT: Hearing on "The Tennessee Valley Authority's Kingston Ash Slide: Evaluation of Potential Causes and Updates on Cleanup Efforts"

PURPOSE OF HEARING

The Subcommittee on Water Resources and Environment will meet on Tuesday, July 28, 2009, at 10:30 a.m., in room 2167 of the Rayburn House Office Building to receive testimony from representatives from the U.S. Environmental Protection Agency (EPA), the Tennessee Valley Authority (TVA), the TVA Office of Inspector General (OIG), and engineering firms. The purpose of this hearing is to receive updates as to the status of the Kingston ash slide cleanup efforts, and also analyses of the root cause of the Kingston surface impoundment collapse.

This hearing is being conducted as one of several hearings that meet the oversight requirements under clauses 2(n), (o), and (p) of Rule XI of the Rules of the House of Representatives.

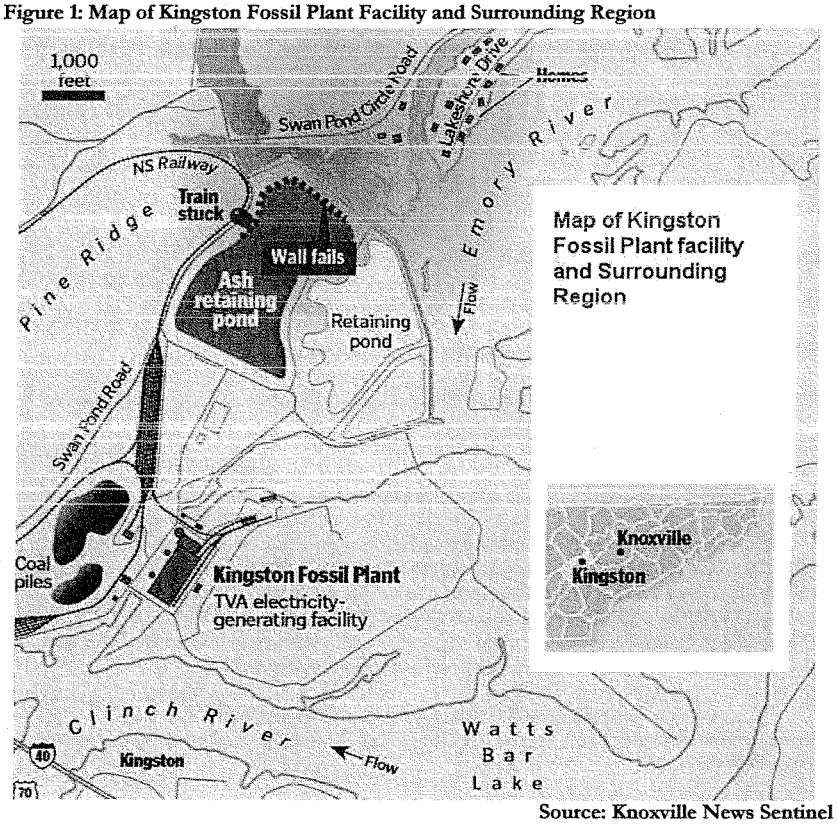
BACKGROUND

This memorandum provides information on the TVA Root Cause Analysis (RCA), as well as other evaluations.

The Kingston Fossil Plant is a coal-fired power plant located in Harriman, Tennessee, 40 miles west of Knoxville, Tennessee. It is owned and operated by TVA. The facility is located at the confluence of tributaries of the Tennessee River: the Clinch and Emory Rivers. It is one of TVA's larger coal-fired power plants and produces 1,700 megawatts per day, or 10 billion kilowatts per year (enough to supply power for 670,000 households). At full power, the Kingston Fossil Plant burns

about 14,000 tons of coal every day. This results in about 1,000 tons of fly ash produced per day. The plant was completed in 1955.

Figure 1: Map of Kingston Fossil Plant Facility and Surrounding Region



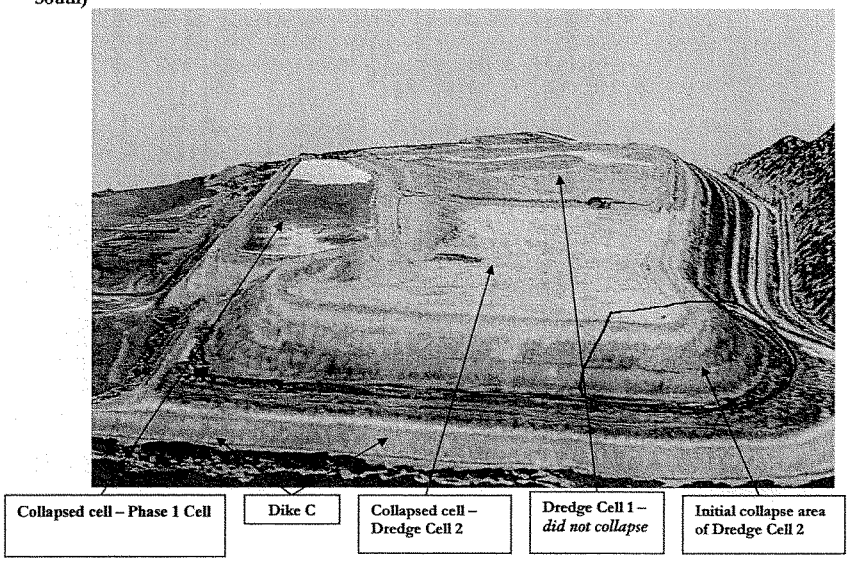
Source: Knoxville News Sentinel

I. December 22, 2008 Ash Spill

At 1 a.m., on Monday, December 22, 2008, a retaining wall failed at a coal ash retention pond at TVA's Kingston Fossil Plant. The breach in the retaining wall resulted in the release of 5.4 million cubic yards of ash and 327 million gallons of water onto land adjacent to the plant, as well as into the nearby Clinch and Emory Rivers. The surface impoundment in question was comprised of Dredge Cell 1, Dredge Cell 2, and the Phase 1 Cell. The northern edge of the impoundment was bounded by a 200 foot wide setback, and then a final dike, Dike C (*see Figure* 2). The dikes were

initially built of naturally silty clays, and then bottom ash and fly ash. On December 22, 2008, Dredge Cell 2 and the Phase 1 Cell collapsed, but, for the most part, Dredge Cell 1 remained intact.

Figure 2: Three-Dimensional View of TVA Kingston Impoundment Pre-Collapse (Facing South)[1]



In terms of actual coverage on the land, over 300 acres have been affected by sludge, at points up to six feet deep. According to the Tennessee Department of Environment and Conservation (TDEC), over 5,000,000 cubic yards of coal ash were deposited into the Emory River and Emory River embayments. The Swan Pond Embayment, an inlet directly north of the impoundment, was largely filled with coal ash. Approximately 110,000 cubic yards were deposited on the ground surface.

EPA noted that the initial release of materials from the plant's retention facility "created a tidal wave of water and ash." While the ash spill rendered three homes uninhabitable and damaged the property of 42 property owners, much of the affected land area impacted by the spill is located on property managed by TVA. Immediately after the spill, a nearby community was evacuated. In addition, power to surrounding communities was disrupted, a major gas line and water main were ruptured, and nearby transportation routes (rail and road) were covered with the ash. No serious

[1] AECOM, *Executive Summary for Root Cause Analysis of Kingston Dredge Cell Failure* (2009) at 9.

injuries were reported as a result of the immediate spill, but one fatality occurred in July 2009 during the clean-up efforts.

II. TVA Root Cause Analysis

In January, 2009, following the collapse, TVA contracted an engineering firm, AECOM, to identify and assess the immediate causes of the impoundment failure. This study is referred to as the RCA. TVA also entered into a contract with a geotechnical consultant, Gonzalo Castro, to peer review the AECOM study while it was being conducted.

Principal Drivers of the Failure: According to AECOM, the initial failure likely occurred in the northwest corner of Dredge Cell 2. The collapse was initially contained within the perimeter of the structure by Dike C. This initial failure was likely followed by a series of rapid and progressive failures that ultimately resulted in the breach of Dike C.

AECOM describes the ash involved in the slide as having undergone static liquefaction. Under these conditions, loose wet ash within Dredge Cell 2 began to flow as if it were a viscous liquid. AECOM and its peer reviewer attribute a loss of strength and stability to have occurred as a function of conditions within the dredge cell that did not allow for proper draining of liquids contained therein (referred to as 'undrained conditions'). This loss of strength and the resultant instability ultimately resulted in the dredge cell failure. This process can also be referred to as a liquefaction failure.

The change from drained (strong, stable) to undrained (weak, unstable) behavior in the dredge cell required a trigger condition, or conditions. According to AECOM, four principal factors worked in conjunction and constituted these trigger conditions. AECOM has stressed that it will not attribute the collapse to any single one of these drivers. AECOM also states that Dredge Cell 2 was "on the verge of deep failure."[2]

1. Increased Loads Due to Higher Fill: Because the Kingston coal ash impoundment could not expand laterally – i.e., its footprint could not get larger – more coal ash required more vertical expansion. For stability reasons, however, each successive layer of coal ash had to have a smaller surface area than the one below it – creating a pyramid, or mound-like structure. Given approximately constant annual ash generation, this resulted in the height of the entire structure growing at increasing rates. AECOM notes, "[t]he added height of ash behind the upstream dike construction added load to the wet ash and to the unusual slimes at the dredge cell foundation level."[3]

2. Fill Geometry and Setbacks: The dikes directly containing the wet ash dredge cells (known as the "upstream dikes") were composed of fly ash and bottom ash, and were also constructed on 35 to 40 feet of wet ash. As such, AECOM found "...the upstream dikes

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[2] AECOM, 2009, *Kingston RCA: Kingston Dredge Cell Failure – Root Cause Failure Analysis, 6/25/09* (http://www.tva.gov/kingston/rca/aecom.pdf (accessed 21 July, 2009)) at 163.
[3] AECOM, *Executive Summary for Root Cause Analysis of Kingston Dredge Cell Failure* (http://www.tva.gov/kingston/rca/FINAL-062609_Executive_Summary-REV3.pdf (accessed 21 July, 2009)) at 5.

did not benefit from the better foundation conditions under the original conditions under the original Dike C, where no slimes were found."[4]

3. Slime Foundation: Prior to the construction of Dike C in 1958, the water-ash slurry was discharged directly into the river. At that time, the water itself extended to the power plant. In other words, the current location of the failed surface impoundment was originally open water. As the ash slurry made its way across the water, the slurry eventually became stagnant and suspended solids (ash components) began to precipitate out. The result "was a thin (less than six inches thick) laminated structure of interbedded flyash, eroded dike soils and re-deposited river sediments within the footprint of the future ash storage cell...This small grained material is referred to as "slimes" as this term applies to the fine-size sediments having a slippery, viscous fill."[5] Slimes are also often found in mine tailing impoundments. Dike C was constructed in 1958, and included a spillway until 1977, over which the liquids from the ash slurry were eventually discharged into the river.

   The slimes identified by AECOM in the Kingston debris field were soft, wet, and had structural characteristics that resulted in their becoming unstable, or creeping. AECOM identified slimes underlying portions of Cell 2, but not in Cell 1 or the Phase 1 Cell. AECOM goes on to note: "Creep failure of the loose slimes was occurring under the loose wet ash, reducing the available strength of the slimes."[6]

4. Loose Wet Ash: The disposal or transport of coal ash in a wet form is alternately referred to as sluiced ash, hydraulically placed ash, or an ash slurry. AECOM found that the wet ash in the failed surface impoundment had not become more dense or consolidated over time. Instead, the wet ash retained a relatively substantial volume of water between ash particles. "As a result, the wet ash remained very loose and susceptible to collapse if subject to rapid loading or rapid displacement."[7]

AECOM has excluded a number of possible other drivers as playing substantive roles in the collapse of Dredge Cell 2. These include rainfall, earthquakes or seismic instability cause by rail traffic, sinkholes or bedrock instability, and instability in the foundation due to groundwater.

Gonzalo Castro, the peer reviewer under contract with TVA to review the AECOM RCA, agreed with the principal AECOM findings.

III. TVA OIG REVIEW OF THE TVA ROOT CAUSE ANALYSIS

The TVA OIG is in the process of evaluating TVA's RCA. The TVA OIG anticipates releasing its report on July 28, 2009. The TVA OIG contracted the engineering firm Marshall Miller & Associates to review the AECOM geotechnical evaluation and findings.

Findings: While the TVA OIG evaluation is supportive of some conclusions in the TVA RCA, it diverges on a number of points. Chief among the TVA OIG findings is that it was not

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[4] *Id.*
[5] *Id.* at 3.
[6] *Id.* at 5.
[7] *Id.*

necessary for all four of the AECOM-identified triggering factors to have been present for the collapse to have occurred. Instead, it was sufficient that less than four of the factors be present for the Kingston collapse to have occurred. The TVA OIG findings include:

1. AECOM's RCA focused disproportionately on the significance of the slime layer as a necessary trigger for the static liquefaction of the ash.

2. More emphasis should have been placed on the role of wet ash in the collapse. The TVA OIG noted that this ash management practice is used at other TVA facilities and could be an instability factor at those sites.

3. The dredge cell and dike construction geometry played a principal role in the collapse. Marshall Miller & Associates have identified these same approaches being used at other TVA surface impoundments and therefore this factor is a cause for concern elsewhere.

IV. LAW FIRM REPORT TO TVA BOARD ON KINGSTON SPILL

Following the Kingston spill, the TVA Board of Directors (Board) retained the law firm McKenna Long & Aldridge LLP (MLA) to advise the Board on its legal duties and potential litigation exposure, as well as to provide other advice related to Board oversight. On July 21, 2009, MLA released a report,[8] based on MLA's factual investigation, on the circumstances surrounding the spill, and that provided recommendations to improve TVA's governance, systems, and controls to reduce the likelihood of similar or other harmful incidents.

On July 21st, 2009, following the release of this report, TVA President and Chief Executive Officer Tom Kilgore states that:

> "We will use it to make improvements in our practices and procedures, and in our organization and its culture. Our goal is always to make sure that TVA's facilities are as safe and efficient as we can make them – for our employees, for our neighbors in the communities where we operate, and for the customers we serve.
>
> We have fallen short of that goal. In retrospect, regardless of the details of the exact failure mechanism, the design and construction of this ash pond was not adequate for the stresses to which it was subjected. We want our neighbors to be proud that TVA is part of their community. We know we have a big job ahead of us in achieving that goal, but we're determined to succeed. It won't be easy, and it won't be quick. But we are committed to get the job done."[9]

MLA's report centers on two fundamental points. First, the AECOM RCA and the scope of work for the TVA RCA, missed what MLA believes is "the fundamental question, which is: did system and culture failures allow such conditions to occur and remain undetected or

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[8] Ide, R. William, III, and Joseph O. Blanco, *A Report to the Board of Directors of the Tennessee Valley Authority Regarding Kingston Factual Findings* (July 21, 2009) (http://www.tva.com/kingston/board_report/mla_kingston_report.pdf (accessed 21 July, 2009)).

[9] Kilgore, Tom, *Remarks by Tom Kilgore at TVA Board Meeting* (2009) (email communication from TVA staff).

unaddressed [?]"[10] The "conditions" MLA refers to are some of the central findings of the AECOM report: height, the wetness of the ash, and the structural geometry of impoundment. Second, MLA found that "the necessary systems, controls, standards and culture were not in place."[11]

Specific MLA findings include:

- **Lack of Clarity and Accountability for Ultimate Responsibility:** The number of TVA groups involved with coal combustion waste led to a lack of accountability. In addition, MLA notes that engineering staff lacked tools or authority to enforce their decisions and recommendations: "The engineers conducted annual inspections, but did not follow-up on the recommendations until the next annual inspection, often repeating the same recommendations year after year."[12]

- **Lack of Standardization, Training and Metrics:** TVA did not have any standard procedures regarding operations and maintenance of wet ash ponds (surface impoundments) at any of the five TVA power plants that produce wet ash. Operations were developed per location by local personnel.[13]

- **Siloed Responsibilities and Poor Communication:** Four separate TVA divisions have responsibilities concerning TVA's coal combustion waste facilities. MLA notes that "communication between the groups was strained and in some instances, non-existent."[14]

- **Lack of Checks and Balances:** The lack of quality assurance and quality control measures for ash storage and disposal facilities "created an environment where employees felt empowered to ignore engineers and 'build it better' than the [engineering] drawings."[15]

- **Lack of Prevention Priority and Resources:** The internal TVA budget process was not adequate to allow for routine maintenance. This created "a situation in which adequate inspections were impossible because the sides of the dikes were overgrown and maintenance needs compounded over time."[16] MLA provided a post-Kingston spill case highlighting this point: "During the remediation efforts following the Kingston Spill, seventeen dump trucks of material were removed from dikes at the Paradise Fossil Plant, which does not include the relatively large trees growing on the dikes, the removal of which had been recommended sporadically in the annual inspection reports since at least 1995."[17]

- **Reactive Instead of Proactive:** TVA management practices included reacting to only the immediate problems and not addressing any systemic management issues that may have driven the problems. The Kingston dredge cell [that ultimately collapsed] developed seeping issues in 2003, and again in 2006. TVA's response was limited to patching the specific leaks. MLA provides a similar example occurring at the TVA Widows Creek facility:

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[10] *Id.* at 2.
[11] *Id.*
[12] *Id.* at 2-3.
[13] *Id.* at 3.
[14] *Id.*
[15] *Id.*
[16] *Id.* at 4.
[17] *Id.*

"...in 2000, Widows Creek experienced an incident very similar to its highly publicized gypsum spill that occurred in January 2009, less than three weeks after the Kingston Spill. The plant's staff determined that the 2000 incident was caused by the failure of an abandoned weir. The fix was to remove the failed weir without addressing the other abandoned weirs at Widows Creek (such as the abandoned weir that gave way in 2009), or any other TVA facility."[18]

PRIOR LEGISLATIVE AND OVERSIGHT ACTIVITY

Since the Kingston spill occurred in December 2008, the Subcommittee has engaged in a number of oversight activities. These include written information requests and briefings from TVA, EPA, the State of Tennessee, and other parties. The Subcommittee held a hearing on the spill on March 31, 2009 titled "The Tennessee Valley Authority's Kingston Ash Slide and Potential Water Quality Impacts of Coal Combustion Waste Storage", and another hearing on the impacts of coal combustion waste storage on water quality on April 30, 2009 titled "Coal Combustion Waste Storage and Water Quality".

[18] *Id.*

WITNESSES

Panel I

The Honorable Mathy Stanislaus
Assistant Administrator
Office of Solid Waste and Emergency Response
United States Environmental Protection Agency

Accompanied by Mr. Stan Meiburg – Acting Regional Administrator, EPA Region 4

Mr. Tom Kilgore
President and Chief Executive Officer
Tennessee Valley Authority

Mr. William H. Walton, P.E., S.E.
Vice President and Senior Principal Engineer
AECOM

The Honorable Richard Moore
Inspector General
Office of Inspector General
Tennessee Valley Authority

Mr. William S. Almes, P.E.
Senior Engineer and Director of Geotechnical Services
Marshall Miller & Associates, Inc.

THE TENNESSEE VALLEY AUTHORITY'S KINGSTON ASH SLIDE: EVALUATION OF POTENTIAL CAUSES AND UPDATES ON CLEANUP EFFORTS

House of Representatives

SUBCOMMITTEE ON WATER RESOURCES AND ENVIRONMENT,
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE,
WASHINGTON, DC.

The Subcommittee met, pursuant to call, at 10:30 a.m., in Room 2167, Rayburn House Office Building, the Honorable Eddie Bernice Johnson [Chairwoman of the Subcommittee] presiding.

Ms. JOHNSON. Good morning. The Committee will come to order.

Today's hearing will begin by offering the Committee's heartfelt condolences to the family of Larry LaCroix of Burlington, Iowa. Mr. LaCroix was part of the Kingston ash spill cleanup operation and was killed in a worksite accident on July the 20th. The Subcommittee extends our thoughts and prayers to his family.

This hearing is being conducted as one of several hearings that meet the oversight requirements under clauses 2(n), (o), and (p) of Rule XI of the Rules of the House of Representatives.

As originally envisioned, today's hearing was to focus on a technical review of the engineering analyses that evaluated the root causes of the December 2008 Kingston coal ash spill. However, since this hearing was originally planned, a number of reports have come to light that demand we look at the collapse, as well as the factors that led to it, with increased scrutiny. I have done so and have come to the conclusion that the causes as identified by TVA are, in fact, not causes at all. Rather, they are symptoms of more endemic issues facing the Tennessee Valley Authority.

As such, this hearing will look to answer three basic questions: First, what geotechnical factors led to the spill; second, what human or management factors contributed to the collapse; and third, what actions will TVA take going forward.

Testimony from Mr. Bill Walton from the engineering firm AECOM will help us answer the first question, based on the AECOM Root Cause Analysis Report upon which his testimony is formulated. We can learn the mechanisms of failure that led to the collapse of the Kingston storage facility.

But that is only a part of the story. The second issue regarding management culture will be addressed by TVA's Inspector General Richard Moore and Bill Almes, an engineer from the firm of Marshall Miller & Associates.

The third issue concerning what steps TVA is planing to take going forward, will be illuminated through this hearing.

This morning's testimony comes in light of today's release of a TVA Office of Inspector General report. It highlights a string of problematic findings regarding TVA's management culture prior to the spill as well as new steps TVA has made in the months following.

Last week the TVA Board released an additional report written by the law firm of McKenna Long & Aldrich that identifies a management culture that, in combination with a lack of accountability, standards, and controls, created conditions that resulted in this spill. In my opinion, these management failures were equally to blame for the Kingston spill and are relevant to the larger debate.

I request unanimous consent that the McKenna report be included in the record.

[The referenced information follows:]

Tennessee Valley Authority
Office of the Inspector General

Inspection Report

REVIEW OF THE KINGSTON FOSSIL PLANT ASH SPILL ROOT CAUSE STUDY AND OBSERVATIONS ABOUT ASH MANAGEMENT

2008-12283-02
July 23, 2009

Memorandum from the Inspector General, ET 4C-K

July 23, 2009

Tom D. Kilgore, WT 7B-K

FINAL REPORT – INSPECTION 2008-12283-02 – REVIEW OF KINGSTON FOSSIL PLANT ASH SPILL ROOT CAUSE STUDY AND OBSERVATIONS ABOUT ASH MANAGEMENT

Attached is the subject final report for your review and action. Your written comments, which addressed your management decision and actions planned or taken, have been included in the report. Please notify us when final action is complete.

This report will not be released to the public before 10 a.m. July 28, 2009. Therefore, please do not distribute this report without prior approval of the Inspector General.

If you have any questions, please contact Robert E. Martin, Assistant Inspector General, Audits and Inspections, at (865) 633-7450. We appreciate the courtesy and cooperation received from your staff during the inspection.

Richard W. Moore

JAL:SDB
Attachment
cc (Attachment):
Chairman Robert M. Duncan
Director Dennis C. Bottorff
Director Thomas C. Gilliland
Director William H. Graves
Director William B. Sansom
Director Howard A. Thrailkill
Robert M. Deacy, Sr., LP 5D-C
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Anda A. Ray, WT 11A-K
Emily J. Reynolds, OCP 1L-NST
Ralph E. Rodgers, WT 6A-K
OIG File No. 2008-12283-02

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EXECUTIVE HIGHLIGHTS

TVA Office of the Inspector General

July 2009

REVIEW OF KINGSTON FOSSIL PLANT ASH SPILL ROOT CAUSE STUDY AND OBSERVATIONS ABOUT ASH MANAGEMENT

On January 8, 2009, after the Kingston Spill on December 22, 2008, the Environment and Public Works Committee held a hearing where Tennessee Valley Authority (TVA) Chief Executive Officer Tom Kilgore testified. The Senators were clear that they wanted answers to what caused the spill and what decisions of TVA contributed to the spill. TVA created the expectation that the root cause analysis that was to be performed would answer those questions.

On June 25, 2009, TVA presented the findings of AECOM through its spokesman Bill Walton and TVA Chief Operating Officer Bill McCollum at a press conference. The report and the presentation by Walton and McCollum produced more questions than answers.

We find that TVA made no effort to publicly disclose what management practices may have contributed to the Kingston Spill.[1] The very tightly scoped AECOM report minimizes TVA management's liability and provides no "lessons learned." TVA has urged everyone just to "move forward" without further examination of what responsibility TVA management may have had for the disaster that occurred on December 22, 2008.

Given the lack of transparency and accountability demonstrated by TVA in failing to properly address the root cause of the Kingston Spill, we believe that limiting the scope of AECOM's work raises questions about TVA's intent. The TVA OIG hired an engineering consultant, Marshall Miller & Associates (Marshall Miller), to perform a peer review of the root cause analysis. In addition the OIG, reviewed prior stability analysis performed both by TVA personnel and by consultants hired by TVA. Based upon our review, we find that: (1) AECOM's focus on the "slimes" layer is misplaced; (2) TVA could have possibly prevented the Kingston Spill by implementing recommended corrective measures; (3) "red flags" existed for years that raised risks that were not captured by TVA's Enterprise Risk Management Program; and (4) the culture within TVA's fossil fuel plants resulted in coal ash being treated like garbage at a landfill rather than treating it as a potential hazard to the public and the environment.

TVA's silence on management practices that contributed to the Kingston Spill is compounded by the failure to report after seven months the stability analysis of TVA's ash ponds that was to have been performed by Stantec. Given Bill Walton of AECOM's statements about the potential vulnerability of TVA's ash ponds, that analysis is critical.

FAILURE TO REVIEW MANAGEMENT PRACTICES

TVA management handled the root cause analysis in a manner that avoided transparency and accountability in favor of preserving a litigation strategy. TVA elected not to publicly disclose management practices that may have contributed to the Kingston Spill. TVA management did not identify any "lessons learned" from the root cause analysis which does not bode well for the future. The emphasis by TVA via AECOM that the unique "slimes layer" was the triggering factor that led to the Kingston Spill is fortuitous for TVA in that TVA can claim: (1) the "slimes layer" was too difficult for TVA to have found, and therefore, TVA's responsibility is lessened; (2) TVA does not have to do anything differently in regard to their ash pond management; (3) TVA management has no culpability, and therefore, no legal liability; (4) there are no adverse implications for the utility industry since Kingston was a "one-off" event caused by a condition not believed to be present anywhere else in the world; and (5) since there are no "slime layers" at any other TVA facility, there is no cause for concern about those other ash ponds.

RECOMMENDED SAFETY MODIFICATIONS NOT MADE

TVA could have possibly prevented the Kingston Spill if it had taken recommended corrective actions. TVA was aware of "red flags" that were raised over a long period of time signaling the need for safety modifications to TVA ash ponds. These "red flags" were raised both by TVA employees and by consultants hired by TVA. Specifically, a 1985 internal memorandum written by a TVA engineer and two 2004 reports by external engineering consultants raised concerns about the stability of the Kingston ash storage facilities. For reasons that are still not entirely clear, appropriate safety modifications were not made. Marshall Miller holds that TVA could have possibly prevented the Kingston Spill if it had implemented the recommended safety modifications.

AECOM OVEREMPHASIZED SLIMES LAYER

Marshall Miller concluded that AECOM's root cause study focused disproportionately on the significance of a thin, discontinuous, soft silt and "slimes" foundation layer as one of the most probable factors/root causes. While Marshall Miller agrees that the four most probable root causes contributing to the Kingston ash pond failure identified by AECOM are technically plausible, reasonably supported by the study data, and that all four contributed significantly to the failure, Marshall Miller concluded that factors other than the "slimes" layer may have been of equal or greater significance . Moreover, Marshall Miller suggested that in assessing the stability of its ash storage facilities, TVA should determine whether any of the four factors contributing to the failure at Kingston exist sufficiently to pose a significant risk of failure. Marshall Miller concluded that TVA's assessment should not be limited to just looking for the existence of the combination of all four contributing factors found at Kingston.

ASH MANAGEMENT NOT SEEN AS A RISK BY TVA

Despite internal knowledge of risks associated with ash ponds, TVA's formal Enterprise Risk Management process, which began in 1999, had not identified ash management as a risk. In 1987, an internal memorandum stated that, "Greater amounts of ash have resulted in expansions of ash ponds. In some instances the dikes that contain this water have become quite high with increasing risk and consequences of a breech. Because of the potential for harm to both surface and groundwater from the failure of a dike, greater attention and establishment of more specific inspection standards for these dikes should be examined." This memorandum triggered internal discussion about whether the ash ponds should have been managed under TVA's Dam Safety Program, which would have required substantially more rigorous inspections and engineering. Ultimately, TVA did not place the ash ponds under its Dam Safety Program.

LEGACY CULTURE IMPACTED ASH MANAGEMENT

Attitudes and conditions at TVA's fossil fuel plant that emanate from a legacy culture impacted the way TVA handled coal ash. Ash was relegated to the status of garbage at a landfill rather than treating it as a potential hazard to the public and the environment. Subsequent to the Kingston ash spill, TVA management began trying to change the way TVA handles coal ash. History, however, suggests that the very best policies and procedures can be successfully resisted by a strong legacy culture. For TVA to be successful in avoiding another Kingston Spill, the culture must be accurately assessed, compliance with new policies and procedures must be faithfully measured with appropriate metrics, and employees must be educated to think differently about ash management than they have over several generations. To do this we believe TVA needs to hire a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout the organization.

[1] This OIG report is the report that was presented to the TVA Board on July 14, 2009. After the OIG briefed the Board on its findings, a specially called Board meeting was held on July 21, 2009, with a press conference that followed. The McKenna Long and Aldridge report that had been commissioned by the Audit Committee of the Board in February of 2009 was released. TVA management acknowledged at the July 21, 2009, meeting many of the management failures that we identify in this report. These admissions reflect the type of transparency and accountability for TVA that the OIG has pressed for some time. We applaud the TVA Board's leadership in this matter and TVA management's acknowledgement of TVA's role in the Kingston Spill.

INTRODUCTION

On December 22, 2008, a major dike failure occurred on the north slopes of the ash pond at the Tennessee Valley Authority's (TVA) Kingston Fossil Plant (KIF). This failure resulted in the release of approximately 5.4 million cubic yards of coal ash spilling onto adjacent land and into the Emory River. While there was no loss of life, 26 homes were either destroyed or damaged. Since the Kingston Spill, TVA has been (1) assessing the geotechnical cause of the spill, (2) developing and implementing a plan to clean up the spill and dispose of the ash, and (3) developing long-term solutions to the issue of ash disposal at all TVA fossil plants. TVA estimates the cost of this spill to be between $675 million and $975 million, not including potential litigation and claims, community recovery support, environmental remediation and long term monitoring, final closure of the failed cell, fines and regulatory costs, and implementation of an alternative to wet stacked fly ash storage at Kingston.

TVA's Chief Executive Officer (CEO), Tom Kilgore, directed the TVA Office of General Counsel (OGC) to contract with a firm to conduct a root cause analysis. He left the selection of the firm to the TVA OGC but did direct that the firm was to be "one of the best." OGC through one of their attorneys arranged for a contract to be drawn between TVA and with AECOM Technology Corporation (AECOM) after AECOM's selection. They also contracted with another consultant, Dr. Gonzalo Castro, P.E., to review AECOM's work. The OGC by contract and verbal instruction severely limited the scope the work of AECOM which we address in some detail in this report. The essence of the direction given to Bill Walton,[1] the chief consultant for AECOM, precluded AECOM from reviewing the (1) standard of practice used by TVA or their consultants for the design and construction of the ash ponds and dredge cells; (2) fate and transport of potential ash and possible contaminates from the cells into the environment; (3) design of remedial construction measures to clean and restore the Kingston site; (4) designs and operations at other TVA wet dredge cell disposal sites. (It should be noted that AECOM provided limited services at a gypsum dredge cell water release at the TVA's Widows Creek facility on January 9, 2009.)

[1] Any opinions attributed to Bill Walton which are outside the scope of AECOM's engagement with TVA do not reflect the opinion of AECOM.

TVA held a press conference on June 25, 2009, at which Bill Walton from AECOM and Bill McCollum, Chief Operating Officer for TVA, briefed the press on AECOM's determination of the root cause of the Kingston Spill. The AECOM report and the statements of Walton and McCollum avoided any comment on any culpability of TVA for the Kingston Spill.

TVA hired Stantec Consulting (Stantec) to assess the condition of its ash ponds and help restructure ash management at TVA. According to TVA management, Stantec is assessing ash ponds under stricter engineering and construction standards than had been applied to TVA's ash ponds in the past (i.e., dam safety standards, as discussed more fully later in this report.)[2] However, as of July 1, 2009, more than 6 months after the spill at Kingston, Stantec has not completed a stability analysis of the remaining dikes at Kingston. In fact, on July 7, 2009, we were informed by a Stantec official that certain procedures required to finalize the stability analysis of the Kingston dikes were not undertaken until approximately mid-June 2009.

The OIG hired an engineering consultant, Marshall Miller and Associates, Inc. (Marshall Miller), to perform an independent peer review of the TVA commissioned root cause analysis by AECOM and provide observations about ash storage facility management at TVA. This report addresses: (1) TVA's failure to address its culpability for the Kingston Spill,[3] (2) TVA's opportunities to implement recommended corrective measures that possibly could have avoided the Kingston Spill, (3) the results of Marshall Miller's peer review, (4) TVA's failure to adequately mitigate known risks for ash ponds at the Kingston site, (5) TVA culture which impacted ash management, and (6) TVA's recent actions to address ash management weaknesses.[4]

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[2] Stantec provides professional consulting services in planning, engineering, architecture, landscape architecture, surveying, environmental sciences, project management, and project economics for infrastructure and facilities projects.

[3] This OIG report is the report that was presented to the TVA Board on July 14, 2009. After the OIG briefed the Board on its findings, a specially called Board meeting was held on July 21, 2009, with a press conference that followed. The McKenna Long and Aldridge report that had been commissioned by the Audit Committee of the Board in February of 2009 was released. TVA management acknowledged at the July 21, 2009, meeting many of the management failures that we identify in this report. These admissions reflect the type of transparency and accountability for TVA that the OIG has pressed for some time. We applaud the TVA Board's leadership in this matter and TVA management's acknowledgement of TVA's role in the Kingston Spill.

[4] The OIG previously reported the results of its assessment of TVA's: (1) emergency response to the spill, (2) communications with the community and media, and (3) reparations to the victims and the community. See Inspection 2008-12283-01, Kingston Fossil Plant Ash Slide Interim Report, dated June 12, 2009.

TVA's CEO provided comments on a draft to this report. The CEO generally agreed with our recommendations and, in addition to identifying actions already taken, stated that actions in-process or planned include:

- Implementing a cultural focusing initiative across the agency, incorporating lesson learns from Kingston.

- Using the detailed, technical explanation of what and how the Kingston dike failure occurred, "to make more specific inquiries as to how the failure could have been prevented in fact and, more importantly, what steps we can take to ensure that it never happens again and to safely close the failed cell."

- Developing and implementing (1) more detailed and rigorous policies and procedures for storing, handling, and maintaining ash and ash disposal facilities and (2) a comprehensive program for future Coal Combustion Product remediation and conversion.

- Implementing enterprise risk management improvements to better achieve the goals of the program.

SUMMARY OF FINDINGS

The Kingston Spill is one of the most significant and costly events in TVA history. The immediate consequence of this disaster includes public doubts created about TVA's commitment to environmental stewardship. As we have pointed out in a previous report on the ash spill, TVA has made great strides in its efforts to make whole the individual victims of this spill, and it has demonstrated a genuine commitment to restore the surrounding area in Roane County, Tennessee, and to make it better than before. Unfortunately, as we discuss in this report, a critical part of remediation is missing. Any restoration for individual victims or the community of necessity involves an acknowledgement of TVA's role in what happened in the early morning hours on December 22, 2008.

- **TVA FAILED TO INVESTIGATE AND REPORT MANAGEMENT PRACTICES THAT CONTRIBUTED TO THE KINGSTON SPILL** TVA pledged early on to find out what caused the Kingston Spill. The reasonable expectation created for TVA stakeholders was that TVA would address not only the technical details of the ash pond failure but also what acts of TVA contributed to the spill. We find that the root cause analysis commissioned by TVA did not investigate what management practices or policies and procedures allowed conditions

to advance to the critical stage that precipitated the spill. TVA's CEO delegated the scoping of the root cause analysis to the OGC, which resulted in a scope that severely limited the value of AECOM's work. Litigation strategy seems to have prevailed over transparency and accountability. Bill Walton of AECOM was discouraged from disclosing information to the public that was relevant and necessary for the analysis of the safety of the remaining Kingston ash ponds and other TVA ash ponds.

- **TVA COULD HAVE POSSIBLY PREVENTED THE KINGSTON SPILL IF IT HAD TAKEN RECOMMENDED CORRECTIVE ACTIONS**
  TVA was aware of "red flags" that were raised over a long period of time signaling the need for safety modifications to TVA ash ponds.[5] These "red flags" were raised both by TVA employees and by consultants hired by TVA. Specifically, a 1985 internal memorandum written by a TVA engineer and two 2004 reports by external engineering consultants raised concerns about the stability of the Kingston ash storage facilities. For reasons that are still not entirely clear, appropriate safety modifications and additional analyses were not made. Marshall Miller holds that TVA could have possibly prevented the Kingston Spill if it had implemented the recommended safety modifications.

- **AECOM OVEREMPHASIZED THE "SLIMES" LAYER AS A TRIGGER FOR THE KINGSTON SPILL, WHICH COULD LIMIT CORRECTIVE ACTIONS**
  In Marshall Miller's opinion, AECOM's root cause study focused disproportionately on the significance of a thin, discontinuous, soft foundation layer (i.e., a sensitive silt and "slimes" foundation layer) as one of the most probable factors/root causes.[6] While Marshall Miller agrees that the fundamental conclusions by AECOM with regard to the four most probable root causes or factors[7] contributing to the Kingston ash pond failure are technically plausible and reasonably supported by the study data, and that all four contributed significantly to the failure,

[5] This report is the work solely of the TVA OIG and its consultant and the findings, conclusions, and recommendations do not represent the views of TVA. The TVA OGC is the arbiter of how rules and regulations, statutory law, and common law apply to TVA. This report should not be interpreted in any way so as to represent or bind TVA in any litigation concerning the Kingston Spill.

[6] Marshall Miller determined that the scope of the root cause study, as presented by AECOM, was sufficient, the methodologies applied reasonable, and the findings technically plausible. However, as discussed in this report, Marshall Miller concluded that the AECOM study results focused disproportionately on the slime layer.

[7] The four most probably root causes identified by AECOM were fill geometry, increased fill rates, soft foundation soils, and loose, wet ash. The upstream-constructed dike configuration on sluiced ash foundation is one of the significant, inherent components of the "fill geometry" factor.

Marshall Miller concluded that factors other than the "slimes" layer may have been of equal or greater significance. Specifically, Marshall Miller concluded that (1) the "fill geometry" is of equal or greater significance and is a condition that may exist in other ash disposal facilities, and (2) the characteristics of the loose, wet ash pose the wet ash as a probable root cause of equal or greater significance to the soft foundation soils.

In addition to independently reviewing the root cause analysis performed by AECOM, the OIG asked Marshall Miller to provide input regarding how to address ash management at TVA. Marshall Miller concluded that in assessing the stability of its wet ash storage facilities, TVA should determine whether any of the four factors contributing to the failure at Kingston exist elsewhere and might pose a substantive risk of failure. Marshall Miller concluded that TVA's assessment should not be limited to just looking for the existence of the combination of all four contributing factors found at Kingston. The goal of the stability assessment, according to Marshall Miller, is for TVA to develop and then implement (where found necessary) appropriate corrective actions to raise the standards of its wet ash storage facilities, targeting engineering and regulatory standards applicable to dams with similar hazard classification. Marshall Miller indicates that there is an unqualified risk of other dike failures if changes are not made in the design and operation of the wet ash disposal operations throughout TVA. Moreover, in Marshall Miller's opinion, had TVA included ash ponds in the Dam Safety Program, the probability of identifying some or all of the conditions that led to the Kingston failure would have increased significantly.

As noted above, TVA precluded AECOM from making these types of recommendations, thus limiting the value of the root cause study. The AECOM lead engineer on the root cause study spent several months examining in detail the conditions at Kingston and thus, in our opinion, would be well positioned to offer recommendations for improving TVA's ash management. Instead of soliciting recommendations from AECOM, TVA hired Stantec to assess the condition of its ash ponds and help restructure ash management.

See Appendix B for Marshall Miller's peer review report on AECOM's root cause analysis and Appendix C for observations and comments on TVA's past ash management practices, and opinions and input regarding how to address ash management at TVA.

- **TVA'S ENTERPRISE RISK MANAGEMENT PROGRAM DID NOT ADEQUATELY ADDRESS KNOWN RISKS ASSOCIATED WITH ASH PONDS**
  Despite internal knowledge of the risks associated with ash ponds, we found no evidence that TVA's formal Enterprise Risk Management process, which began in 1999, had identified ash management as a risk. An Enterprise Risk Management system is designed to identify and mitigate risks that could adversely affect the organizations ability to achieve their mission and objectives. Risks associated with ash management that were known internally as early as 1987 were not adequately mitigated.

  In 1987, an internal memorandum from the TVA Director of Environmental Quality to the TVA Manager of Policy, Planning, and Budget stated that, "Greater amounts of ash have resulted in expansions of ash ponds. In some instances the dikes that contain this water have become quite high with increasing risk and consequences of a breech. Because of the potential for harm to both surface and groundwater from the failure of a dike, greater attention and establishment of more specific inspection standards for these dikes should be examined." This triggered discussion among some in TVA about whether the ash ponds should have been managed under TVA's Dam Safety Program,[8] which would have required substantially more rigorous inspections and engineering. Some managers and executives within TVA took the position that doing so was unnecessary for safety, and TVA was not technically required to do so; ultimately, TVA did not place the ash ponds under its Dam Safety Program.

- **THE CULTURE AT TVA'S FOSSIL FUEL PLANTS IMPACTED ASH MANAGEMENT**
  Our review disclosed attitudes and conditions at TVA's fossil fuel plants that emanate from a culture that impacted the way TVA handled coal ash. Over the last nine months the OIG has conferred with the TVA Board and TVA management about what we perceive to be systemic problems that have their genesis in the culture. While we recognize that there is no one culture at TVA and instead there are subcultures that vary from one organization to another within TVA, there are common themes we find antithetical to the level of transparency and accountability expected of a public utility. While the

[8] TVA's Dam Safety Program seeks to ensure the structural integrity and safe operation of TVA's 49 dams and appurtenant structures, instrumentation to monitor dam performance, periodic inspections, maintenance and repairs, and emergency preparedness. The Dam Safety Program is also responsible for saddle dams and dikes in the TVA system. The TVA Dam Safety Officer is responsible for ensuring that TVA's Dam Safety Program meets federal guidelines for dam safety.

culture at TVA's fossil fuel plants is not the cause of the Kingston Spill, the culture, in our view, contributed to the spill, and it is likely to be resistant to the kinds of reforms necessary to avoid other safety failures.

TVA culture at fossil fuel facilities relegated ash to the status of garbage at a landfill rather than treating it as a potential hazard to the public and the environment. We believe this resulted in significant weaknesses in ash management practices across TVA, including: (1) a failure to implement recommended corrective actions that could have possibly prevented the Kingston Spill; (2) the lack of policies and procedures; (3) poor maintenance; (4) the lack of specialized training; (5) multiple organizational structure changes; (6) inadequate communication; and (7) a failure to follow engineering best practices.

TVA management is now implementing new policies and procedures to change the way TVA handles coal ash. History, however, suggests that the very best policies and procedures can be successfully resisted by a strong legacy culture. For TVA to be successful in avoiding another Kingston Spill, the culture must be accurately assessed, compliance with new policies and procedures must be faithfully measured with appropriate metrics, and employees must be educated to think differently about ash management than they have over several generations. We believe TVA needs a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout TVA.

- **TVA HAS RECENTLY ACTED TO ADDRESS CERTAIN ASH MANAGEMENT WEAKNESSES**
  Since the Kingston ash spill, TVA management has begun to reassess its ash management program and has taken several actions to improve ash management across the agency. These actions include (1) organizational changes to address management and accountability issues, (2) changes designed to change the corporate culture which had de-emphasized the importance of ash management, and (3) steps to assess ash storage facilities against dam safety guidelines with the goal of complying with dam safety guidelines where possible.

FACTUAL BACKGROUND

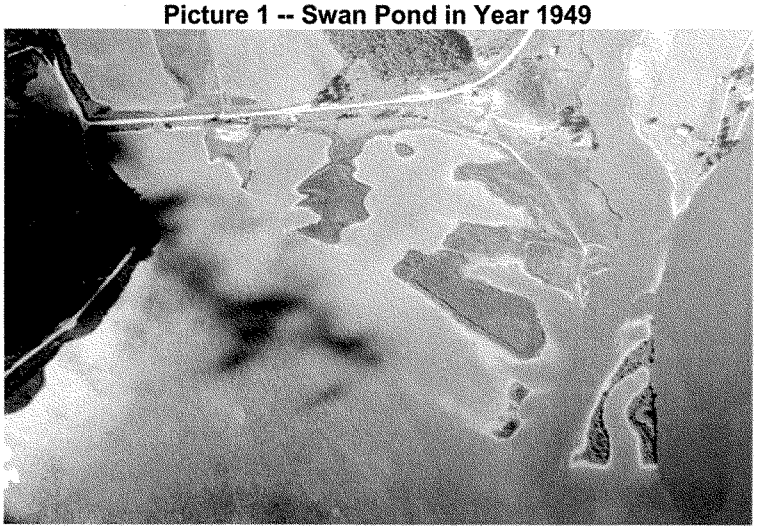
ASH PONDS

Coal ash is what is left after coal is burned in power generating plants. Fly ash, captured by electrostatic precipitators, and bottom ash, taken from the boilers, are mixed with water and pumped to the ash containment ponds. KIF produced 1,000 tons, or 1,200 cubic yards, of coal fly ash daily when operating at full capacity.

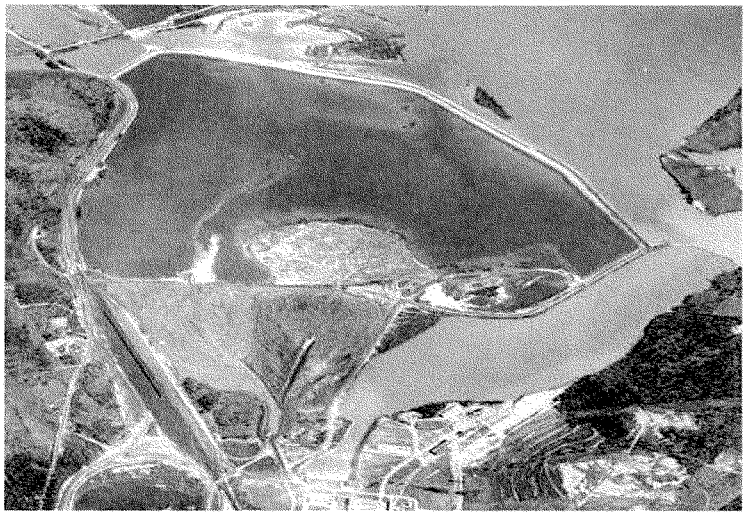
Since the 1950's, TVA's KIF has been storing its coal ash in containment ponds at the plant site, which is adjacent to the Emory River. The initial KIF ash pond was built over the former Swan Pond Creek flood plain, which is illustrated by Picture 1 on page 9. By 1965, the initial ash pond was filled. Picture 2 on page 9 illustrates the configuration of the initial ash pond. After the initial ash pond was full, a settling pond and ash storage (i.e., dredge) cells were constructed. The ash storage area was subdivided into smaller dredge cells. The dredge cells consisted of perimeter dikes that were stacked on top of each other and upon previously sluiced ash materials. At KIF, the specific process for moving ash from the plant to the dredge cells included:

- Mixing ash with water in the plant and pumping it to a settling pond.
- Dredging the ash after it settled to the bottom of the pond.
- Pumping the dredged wet ash into the storage cells.

Picture 1 -- Swan Pond in Year 1949



Picture 2 -- KIF Ash Pond in 1962



TVA plant personnel visually inspected the dikes daily. TVA's engineers performed a more comprehensive inspection annually. The Tennessee Department of Environment and Conservation (TDEC) also inspected the ash pond dikes quarterly. In 2003 and 2006, small localized slope failures occurred on the dikes of the ash pond which were addressed by TVA with the assistance of a consulting engineering firm. The last TDEC inspection was in August 2008, and no deficiencies were found. The last KIF ash pond daily visual inspection was Sunday afternoon, December 21, 2008. No problems were noted.

On December 22, 2008, the north and central portions of the ash disposal site failed shortly before 1 a.m. EST, an estimated 5.4 million cubic yards of ash were released in a progressive sequence of flow slides over a period of one to two hours. The release extended over approximately 300 acres outside the ash storage area, causing damage to 26 homes, disrupting electrical power, rupturing a natural gas line in a neighborhood located adjacent to the plant, and covering a railway and road in the area. The flow slide extended northward approximately 3,200 feet beyond the limits of the original ash pond over the Swan Pond Creek flood plain, a back water slough of the Emory River and into the former Emory River channel of Watts Bar Reservoir. The ash disposal cell which failed had been permitted by TDEC as a Class II Solid Waste Landfill under state regulations.

ASSESSING THE ROOT CAUSE

As we have noted earlier, TVA's CEO Tom Kilgore tasked the OGC with contracting with an expert to do a root cause analysis. OGC retained AECOM in early January 2009 to conduct an independent analysis to determine the root cause of the KIF dike failure. AECOM is a global provider of professional technical and management support services to a broad range of markets, including transportation, industrial facilities, environmental, and energy. TVA's OGC also retained Dr. Gonzalo Castro to provide advice and assistance and peer review the root cause analysis. Dr. Castro is a civil engineer with more than 35 years of experience in geotechnical engineering. He is a recognized expert in seismic analysis and earthquake engineering. As part of the root cause analysis, AECOM (1) drilled 147 sampling borings; (2) located, surveyed, and logged identifiable relics; (3) conducted interviews to establish timelines; (4) reviewed existing TVA records to establish filling and flooding history; and (5) performed seepage and stability analyses. As noted above, the root cause analysis was limited to determining the more probable factors contributing to the Kingston failure.

The OIG retained Marshall Miller to perform an independent peer review of the TVA commissioned root cause analysis by AECOM. Marshall Miller has expertise in coal ash and other waste materials, containment design for hydraulically placed or sluiced ash and mine tailings, earthen and mine waste dams and, more generally, materials science and geotechnical engineering. Marshall Miller's peer review of AECOM's root cause analysis is presented in the attached Appendix B. A summary of Marshall Miller's conclusions and observations is presented in the following section.

FINDINGS

TVA FAILED TO INVESTIGATE AND REPORT MANAGEMENT PRACTICES THAT CONTRIBUTED TO THE KINGSTON SPILL

Great Expectations

In the aftermath of December 22, 2008, when asked about TVA decision making prior to the Kingston Spill, TVA officials repeatedly pointed to the root cause analysis report to come. For example, at the hearing before the Senate Environment and Public Works Committee on January 8, 2009, Senator Barbara Boxer's query to CEO Tom Kilgore as to what steps TVA would have done differently, Kilgore replied that he ".....would like to get the failure investigation complete and know exactly what the cause was."[9] Senator Boxer was clear in questioning Kilgore at the hearing that answers were expected not just about the technical physical failure of the ash pond at Kingston, but that answers were expected from TVA as to TVA's culpability in managing the ash ponds.[10] Kilgore's written testimony included a statement that, "We are beginning an independent, in-depth root cause analysis to determine why the ash pond dike failed."[11]

Clearly, a reasonable expectation was created for Congress and TVA's other stakeholders that since January of 2009, TVA has been working diligently to explain why the Kingston ash spill occurred. It was not foreseeable that, in fact, TVA would not review what management practices may have contributed to the failure, but would instead tightly circumscribe the scope of review to intentionally avoid revealing any

[9] U.S. Senate Committee on Environment & Public Works, Full Committee hearing entitled, "Oversight Hearing on the Tennessee Valley Authority and the Recent Major Coal Ash Spill," Thursday, January 8, 2009.

[10] "A lot of questions surrounding your decision making prior to the failure." *(Emphasis added)*, [U.S. Senate Committee on Environment & Public Works, Full Committee hearing entitled, "Oversight Hearing on the Tennessee Valley Authority and the Recent Major Coal Ash Spill," Thursday, January 8, 2009.

[11] Written testimony of Tom Kilgore, President and Chief Executive Officer, Tennessee Valley Authority, before the Environment and Public Works Committee, January 8, 2009.

evidence that would suggest culpability on the part of TVA. In fact, it appears that TVA management made a conscious decision to present to the public only facts that supported an absence of liability for TVA for the Kingston Spill.

No "Could Have, Would Have, Should Have" For TVA: Let's Just All Move Forward

On June 25, 2009, TVA held a press conference to deliver AECOM's root cause analysis report. Bill Walton of AECOM appeared for his company and COO Bill McCollum represented TVA at the press conference. The presentation was tightly scripted to avoid any discussion of management errors at TVA. This is best captured by the following exchange by a member of the media and COO Bill McCollum:

> **Question**: "Well, should it have been, should TVA or TDEC have been more observant before that permit was issued to have discovered it? I mean it said it was a stable facility and apparently it wasn't."
>
> **McCollum**: "Well, I think that if you take what's been learned from the root cause analysis and from what Mr. Walton said about the depth of inquiry and investigation that it took to find some of the things that are reported here in the analysis, it's pretty hard for me to go back and say could have, would have, should have about things that you might have found at some point in the past."
>
> Repeated efforts by the media to learn anything about TVA's culpability were met with artful dodges. Clearly, both McCollum and Walton had been schooled in how to deflect any question that would elicit an answer that would suggest legal liability for TVA. The apparent agreed upon program was to avoid going back and second guessing TVA decisions and to counsel the media to focus only on the future. An example of the delicate tap dance required is shown in the following exchange between the media and Bill Walton.
>
> **Question**: "Not that you would have, but had you done your analysis prior to the event and noticed the slime layer and noticed sort of all of this coming together as one, what would you have recommended at the time? Would there have been a way to stop it, fix it, or would you have to shut it

down? What would you do had you discovered all of these factors prior?"

Walton: "I think that's the challenge of coming to this and doing this study. It presents the position of going forward on lessons learned. Hindsight is 20/20. Let's take the lessons learned and move forward."

Not once during the press conference was even a begrudging acknowledgement made that TVA could have done anything differently. On the contrary, as seen above, the emphasis was on how difficult it was for AECOM to discover the cause of the Kingston Spill (mostly the "slime" layer) and by inference TVA could not be expected in the exercise of due diligence to have discovered a problem. Even the building of the ash pond over the lake in the '50's was forgiven by Walton as demonstrated by this exchange with the media.

Question: "If you were building it now, would you say that's probably not a good site?"

Walton: "It would be different criteria. Not that it couldn't be built, but perhaps in '51 or '54 you would have to know the ultimate fate of the structure. And I don't know that anyone then knew what the geometry would be with the Clean Air and Clean Water Act. So there are circumstances of policy there, that affect that answer."

Most telling perhaps was the defense put forward by Walton that TVA could not have discovered the "slimes" layer which was the focus as the triggering mechanism for the spill. This defense was articulated in response to another question by the media:

Question: "Dr. Walton, was there anything in your review of the previous stability analysis and other historic documents from TVA that would have or should have raised a red flag for anyone reviewing those documents, say in the immediate aftermath of their creation? I mean if there was a stability analysis in 1981 was there anything in that one or any of the others that would have said oh we should investigate this site further before the stack height or take any other measures?" *(Emphasis added)*

> **Walton**: "Yes, we did look at earlier stability analyses as part of the root cause analysis. And in that root cause analysis, we had to look at the facts that were in front of us. And those signs simply were not identified in those, and it took us two-and-a-half months to find that. So I guess it's lessons learned to move forward." *(Emphasis added)*

While both Walton and McCollum cautioned that the focus should be on "lessons learned" and moving forward, it is not entirely clear what lessons TVA has learned. Since, according to TVA via its representatives, there were no "red flags" that TVA could have spotted to take corrective actions, and since TVA cannot say that even building the ash pond out on a lake bed was a bad site, what exactly were the "lessons learned going forward?" If as it appears TVA is saying that the "slimes" layer is a unique phenomenon appearing only if TVA builds an ash pond out on a lake bed and TVA does not intend to build an ash pond on a lake bed, what structural defects or management practices need to be avoided "going forward"? We have examined the press conference presentation on June 25, 2009, with some care. We have yet to discover one "lesson" TVA says that it learned. This does not bode well for the future.

We know that TVA has, in fact, learned from the December 2008 spill, and we know that because of the management changes that we report in the final section of this report. We believe that TVA should state publicly those lessons learned and that list would include, among others:

1. Building the original ash pond over a lake bed was a faulty design;

2. Corrective actions recommended both by TVA employees and by consultants should have been implemented;

3. Stacking ash to the heights contemplated at Kingston was a bad idea;

4. Not having policies and procedures for ash management contributed to the spill;

5. A culture that minimized the importance of ash management needs to be changed; and

6. Wet ash ponds should comply with dam safety standards rather than with landfill standards.

TVA's Dilemma: Accountability or Litigation Strategy?
TVA had a clear but difficult choice to make in the aftermath of the Kingston Spill. One choice was to conduct a diligent review of TVA management practices as well as to conduct a technical physical examination of the failed structure and then to publish whatever was discovered to the world. The second choice was to "circle the wagons," carefully craft press releases to project TVA in the most favorable light,[12] and to tightly control any reports done by TVA of the failure to minimize legal liability. The first choice required a value judgment that a government agency causing a major disaster affecting the lives and property of citizens around the Kingston Fossil Fuel Plant should err on the side of transparency and accountability. The downside to this choice is providing fodder for plaintiffs in litigation against TVA and bringing perhaps additional scrutiny on the agency.

The second choice also required a value judgment. That choice placed a premium on the preservation of TVA assets and the protection of an image of environmental stewardship. The advantage of this choice was limiting legal liability which arguably inures to the benefit of ratepayers and avoiding scrutiny of TVA management practices that might have contributed to the Kingston Spill.

We are not privy to the calculation made by TVA as to the relative merits of these two difficult choices. We are, however, privy to facts that suggest a predictable outcome from TVA electing to go with the second choice. First, we have found no evidence of any intention on the part of TVA to require AECOM to conduct a review of management practices that might have contributed to the Kingston Spill. During the course of the root cause study, TVA never claimed that a review of their management practices, policies, and procedures or consultants' reports would be publicly disclosed.[13] Second, the decision to delegate from the CEO to the OGC the responsibility of managing the root cause study predetermined the choice that would be made between accountability and litigation strategy. The OGC did what good lawyers do; they defend their client. TVA's lawyers do not make TVA policy and do not determine the degree of

[12] See OIG report, Inspection 2008-12283-01, Kingston Fossil Plant Ash Slide Interim Report, dated June 12, 2009, where we examined TVA's response to media inquiries immediately after the Kingston Spill.

[13] TVA has shown a belated interest in this in response to the Inspector General's probing about whether such a review was being conducted by TVA. Six months after the Kingston Spill, however, no review by TVA of management practices has commenced. We conclude that TVA did not intend to conduct such a review.

transparency or accountability for TVA. Third, the power to write the scope of the root cause study carried with it the inherent power to prevent disclosures that could potentially be damaging to TVA's defense against litigation from plaintiffs claiming damages from the Kingston Spill. Obviously, the more narrow the scope, the better for those entrusted with defending TVA in court.

Finally, the relationship created here was not with TVA generally and the Office of Legal Counsel but was instead between the OGC and AECOM. It was the lawyers who controlled the engagement whether they were the actual lawyers going to court to defend TVA or merely lawyers in the same office.

We should make clear that we are not suggesting that the facts recited above indicate any lack of independence of AECOM or more particularly any lack of independence of Bill Walton. On the contrary, our observation is that Bill Walton is the consummate professional not susceptible to any undue influence. Nor did we find any evidence of any effort to influence Walton's work. His conclusions as to the root cause appear to be based entirely upon his forensic work as a respected expert in his field.

The OIG interviewed Walton on two occasions. He stated AECOM was retained by TVA OGC to perform a root cause analysis of the December 22, 2008, dredge cell failure to determine the most probable cause(s) and location of the failure at the site. AECOM was also retained to provide peer review of remedial containment designs by Stantec and Geosyntec at Kingston and to check if the designs are consistent with post-failure geotechnical conditions encountered in AECOM investigations and to peer review ash handling, restoration and containment designs by Stantec and Geosyntec at the Kingston site to check if designs were/are consistent with the post-failure geotechnical conditions in AECOM investigations. He made it clear that he had been specifically directed not to, among other things, review the: (1) standard of practice used by TVA or their consultants for the design and construction of the ash ponds and dredge cells; (2) fate and transport of potential ash and possible contaminates from the cells into the environment; (3) design of remedial construction measures to clean and restore the Kingston site; (4) designs and operations at other TVA wet dredge cell disposal sites. (It should be noted that AECOM provided limited services at a gypsum dredge cell water release at the TVA's Widows Creek facility on January 9, 2009.) In our opinion, the defined limitations in scope precluded AECOM from (1) reviewing or judging the management practices of TVA in conjunction with the design, construction, or operation of TVA ash ponds; (2) determining fault for the Kingston Spill; and (3) judging TVA employees

or contractors. These restrictions placed on AECOM are consistent with a sound litigation strategy but are inimical to transparency and accountability for TVA. This is particularly true since TVA has evidenced no intention to address the areas listed above through either TVA management or anyone else.

We conclude that TVA defaulted to a preference for litigation strategy over transparency and accountability once the root cause study was turned over to the lawyers. Our conclusion is buttressed by TVA's obvious decision not to conduct a review of its management practices either as part of the root cause analysis or by a separate review. As far as the root cause analysis, the constraints placed on Bill Walton appear to have been intended to avoid any such review. While it would have increased the delay in announcing a root cause, having Walton review TVA's management practices would have allowed a recognized expert to provide a measure of transparency and accountability that is sorely lacking.

When the OIG interviewed Bill Walton he offered opinions that were not made a part of his written report or stated at the June 25, 2009, press conference. First, based on Walton's root cause analysis report and information presented to Walton by Stantec early in May 2009, and conditioned on Walton fully investigating such issues, Walton believes there may be an issue with other TVA ash ponds built on soft clay that may be particularly vulnerable to static and seismic loading or disturbance. That, according to Walton, is particularly true for those ash ponds in West Tennessee closer to the New Madrid Seismic Zone. Secondly, Walton expressed the belief that it might be more appropriate to treat wet ash ponds, like the one at Kingston, as a tailings dam designed to contain wet ash and hold water as opposed to treating such ash ponds as a landfill. Finally, conditioned on Walton fully investigating hypothetical failures, Walton believed that continually stacking the ash, like TVA was doing before the spill, might lead to an eventual breach. None of these positions has been reported by TVA. Given the expertise Walton has and the substantial fee paid to AECOM, TVA and TVA stakeholders would have been better served by TVA eliciting and sharing this information with the public.

Finally, we note that the conclusion reached by AECOM that the slime layer was a triggering device for the Kingston Spill enhances TVA's litigation efforts against claimants. The point was repeatedly made at the June 25 press conference that the slime layer was unique to Kingston and not found at any other TVA ash pond. AECOM did not attribute the failure to TVA's design of the ash pond or to TVA's operation of the ash pond. Walton, as noted earlier, even declined to say that building an ash dike out

on a lake bed was not a good idea. Does TVA know that building an ash pond over a lake bed is a bad idea? This is apparently not a "lesson learned" based on what TVA and its consultants are willing to say publicly.

Tagging the "slime layer" as the triggering mechanism for the Kingston Spill is fortuitous. The outcome for TVA results in TVA being able to claim that: (1) the "slimes layer" was too difficult for TVA to have found, and therefore, TVA management's liability is minimized; (2) TVA does not have to do anything differently since no fault was found in either the design of the ash pond or in the operation of the ash pond; (3) TVA management has no culpability because they couldn't have found the cause of the spill, and therefore, no legal liability; (4) there are no adverse implications for the utility industry since Kingston was a "one-off" event caused by a condition not believed to be present anywhere else in the world; and (5) since there are no "slime layers" at any other TVA facility, there is no cause for concern about those other ash ponds. As Marshall Miller points out later in this report, AECOM's emphasis on the "slime layer" is misplaced and inappropriately diminishes the role that the design and operation of the Kingston ash pond played in the spill. For all of these reasons, we conclude that TVA's explanation of the root cause of the Kingston Spill is suspect.

Perhaps some would say that it is unrealistic that a government agency would choose to disclose information that could be either embarrassing or that could create legal liability. It is certainly true that there are at times legitimate reasons for a government agency to withhold information from the public. We fail to see where that is the case here.

TVA COULD HAVE POSSIBLY PREVENTED THE KINGSTON SPILL IF IT HAD TAKEN RECOMMENDED CORRECTIVE ACTIONS

TVA had been made aware of certain "red flags" that were raised over a long period of time signaling the need for safety modifications to TVA ash ponds. These "red flags" were raised both by TVA employees and by consultants hired by TVA. Specifically, a 1985 internal memorandum written by a TVA engineer and two 2004 reports by external engineering consultants raised concerns about the stability of the Kingston ash storage facilities. For reasons that are still not entirely clear, appropriate safety modifications were not made. Marshall Miller holds that TVA could have possibly prevented the Kingston Spill if it had implemented the recommended safety modifications.

In April 1985, an internal memorandum written by a TVA engineer raised serious concerns about the stability of Dike C of the Kingston ash storage facility.[14] This memorandum states that Dike C had not been built according to design drawings. It further states that the dike's "as built" factor of safety was less than desirable and therefore recommended that plant personnel inspect Dike C daily. When asked by the OIG to review this memorandum, Marshall Miller stated that the memorandum:

> *which indicate that the calculated factor of safety was less than the minimum acceptable value of 1.5 and close monitoring was recommended to detect any potential signs of failure in lieu of changing TVA policies and procedures that would require that the ash pond would be designed to the higher "dam safety" standard.[15] The construction of successive upstream stages to elevations 820 (approximate crest elevation of Dredge Cell No. 2 at the time of failure) above the original containment dike system ("Perimeter Dike C" – approximate crest elevation of 748 feet) may have contributed to an additional decrease in the factor of safety of the containment dike system. In essence, at the time of failure on December 22, 2008, this increase in constructed height equated to an approximate 70-foot increase in the height of the ash pond above the crest elevation of the original Perimeter Dike C.*

In June 2004, Worley Parsons (Parsons) reported on the results of a slope stability analysis it performed at TVA's request related to the design of an upward expansion of the Kingston coal pond. At the time of the spill, the expansion design had been approved by TVA and some of the work completed. This upward expansion would have resulted in more of the ash being piled into the cell that later spilled. In its report, Parsons noted the existence of an approximately 7- to 10-foot thick layer of loose ash immediately overlaying the clay soil beneath the ash pond. Parsons further noted that this layer of loose ash may undergo liquefaction[16] under certain circumstances, including a seismic event. Parsons stated that the probability of this occurring was "extremely low." However, they then

[14] This memorandum, dated April 3, 1985, was from TVA's Director of Engineering projects to TVA's Director of Fossil and Hydro power. The memorandum subject was: *"Kingston Steam Plant – Dike C Soils Investigation and Engineering Study Results."*

[15] As discussed later in this report, designing to dam standards would have required a significantly higher level of engineering, inspection, stability analyses, and the like.

[16] Dictionary.reference.com defines liquefaction as the process by which sediment that is very wet starts to behave like a liquid. Liquefaction occurs because of the increased pore pressure and reduced effective stress between solid particles generated by the presence of liquid. It is often caused by severe shaking, especially that associated with earthquakes.

stated that methods of predicting liquefaction have proven to be "insufficient" and, therefore, recommended that TVA take measures to improve drainage in the ash pond. When we inquired with TVA officials as to whether this recommended drainage system had been installed, we learned that it had not.

We also found that TVA contracted with a second consulting firm, Geosyntec, to conduct an engineering peer review of coal byproduct (gypsum and ash) plans for the Kingston plant, including the stability analyses completed by Parsons pertaining to the ash pond expansion design. According to a TVA manager, TVA hired Geosyntec to perform the peer review because of questions about the quality of the Parsons' study. Geosyntec reported the results of its work to TVA in November 2004. With regard to the proposed drainage system and liquefaction, Geosyntec found that (1) an analysis estimating the liquefaction potential of the ash layer was not performed and therefore the need for the drains was not determined, and (2) the effect the drains would have had was not calculated and, therefore, it is unclear whether the drains would have been effective at mitigating liquefaction. In its report to TVA, Geosyntec concluded that the "potential for liquefaction should be estimated and, depending on the results of this estimate, a liquefaction analysis may be required. If the site is expected to liquefy then ground improvement techniques need to be implemented." *(Emphasis added)* In addition, Geosyntec questioned certain aspects of the stability analysis performed by Parsons and made recommendations pertaining to stratigraphy,[17] design material/soil property, slope stability evaluation, and veneer stability analyses.

When asked whether the Geosyntec recommendations had been followed, TVA officials responded that they had not. The TVA CEO remarked that he had noted the significance of the Geosyntec study and inquired internally why the recommendations had not been implemented; according to the CEO, he was unable to ascertain why.

When asked to review the 2004 Parsons and Geosyntec reports for the OIG, Marshall Miller concluded that the Geosyntec report should have served as a clear warning to TVA regarding the stability of the Kingston ash storage facilities. Marshall Miller stated that it was evident from the findings and recommendations in the Geosyntec report that the expansion design should have been modified to conform to a more stringent design configuration. Upon completion of the proposed expansion, which had not occurred at the time of the failure, more height and weight would have

[17] Per PhysicalGeography.net, stratigraphy refers to the subdiscipline of geology that studies sequence, spacing, composition, and spatial distribution of sedimentary deposits and rocks.

been added to what is now the failed ash pond. Marshall Miller told us that TVA's implementing the Geosyntec recommendations would have resulted in additional extensive analyses and modeling. Marshall Miller concluded that the recommendations made by Geosyntec were appropriate and the failure of the TVA to respond to such warnings and complete necessary revisions to the design shows that conservative engineering design principles were not being followed within the TVA. Furthermore, had corrective measures been taken in a timely fashion, it is possible that TVA could have potentially prevented the occurrence of the failure. *(Emphasis added)*

On June 1, 2004, TVA submitted an application to TDEC for the upward expansion of the Kingston ash pond facility. This application was approved by TDEC on September 12, 2006. TVA provided the Parsons' study to TDEC as part of the permit application. However, TDEC was unable to find documentation that the Geosyntec study was provided to them. The TDEC permit requires TVA to submit any relevant facts it becomes aware were not submitted. Specifically, the permit says, "Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Commissioner, it shall promptly submit such facts or information."

We conclude that Marshall Miller's review of these various engineering reports demonstrates that TVA was on notice about safety issues and that those safety issues were not addressed by TVA. TVA does not appear to have an answer as to why these issues were not properly addressed. Contrary to the position seemingly taken by AECOM at the June 25, 2009, press conference, the prior engineering reports were "red flags," and TVA could have taken corrective action that could have possibly avoided the Kingston Spill.

AECOM OVEREMPHASIZED THE "SLIMES" LAYER AS A TRIGGER FOR THE KINGSTON SPILL, WHICH COULD LIMIT CORRECTIVE ACTIONS

In Marshall Miller's opinion, AECOM's root cause study focused disproportionately on the significance of one factor -- the thin, discontinuous, soft foundation layer (i.e., a sensitive silt and "slimes"

foundation layer) as one of the most probable factors/root causes.[18] While Marshall Miller agrees that the fundamental conclusions by AECOM with regard to the four most probable root causes or factors[19] contributing to the Kingston ash pond failure are technically plausible and reasonably supported by the study data, the AECOM study suggests that the failure of December 22, 2008, depended on all four factors working in combination. In Marshall Miller's professional opinion, only some of the four factors could have acted together to cause the failure. In addition, Marshall Miller concluded that factors other than the "slimes" layer may have been of equal or greater significance. Specifically, Marshall Miller summarized that (1) the "fill geometry" is of equal or greater significance to the "soft foundation soils" and might be similarly critical at other upstream-constructed wet ash disposal facilities, and (2) the characteristics of the "loose, wet ash" pose the wet ash as a probable root cause of equal or greater significance to the "soft foundation soils."

A discussion of (1) AECOM's scope and methodology and technical determination of what caused the Kingston Spill, and (2) Marshall Miller's conclusions regarding the AECOM root cause analysis and other observations follows.

AECOM's Scope and Methodology

AECOM executed a consulting agreement with TVA's OGC on January 16, 2009, and commenced a data review phase shortly thereafter. AECOM's scope of work was limited to the identification of the likely initiator(s) ("root cause(s)") of the failure, which inherently encompasses consideration of potential failure modes, possible "initiators" or "triggers" of the onset of failure, and factors that contributed to its progression.

As field samples and observations became available, AECOM started the laboratory testing and analytical phases of the project, which was completed in June 2009. The purpose of the laboratory testing program was to characterize the native soils and non-native site materials and determine their geotechnical and mechanical properties to allow AECOM to analyze their behavior under the conditions prevailing on-site at the time of the failure. AECOM also performed multiple engineering analyses of

[18] The OIG contracted with Marshall Miller to perform an independent peer review of the root cause analysis conducted by AECOM. Marshall Miller's work included a review of site investigations, evaluations, analyses, and findings and conclusions prepared by AECOM relating to the ash pond failure. The final root cause analysis report was published by AECOM on June 25, 2009. Notably, Marshall Miller did not conduct a parallel investigation to AECOM's. Marshall Miller's professional opinions are based principally on review of various documents, briefings provided by AECOM, and a review of their root cause analysis report.

[19] The four most probable root causes identified by AECOM were fill geometry, increased fill rates, soft foundation soils, and loose, wet ash. The upstream-constructed dike configuration on sluiced ash foundation is one of the significant, inherent components of the "fill geometry" factor.

the data obtained from site surveys and laboratory test results, as well as undertaking an extensive compilation and review of documents from TVA's archives.

AECOM's Determination of Cause
AECOM determined that the four probable root causes of the Kingston ash pond failure were:

1. Fill geometry (upstream-constructed dike configuration on sluiced ash foundation)
2. Increased fill rates (increased loads and loading rates due to higher fill levels and shrinking footprint)
3. Soft foundation soils (weak, sensitive silt and slimes foundation layer prone to creep)
4. Loose, wet ash (very loose hydraulically placed/sluiced ash is susceptible to collapse if subjected to rapid loading or rapid displacement)

AECOM specifically characterized the root cause of the failure as a complex set of conditions, including a long-evolving combination of the high-water content of the wet ash, the increasing height of the ash, the construction of the sloping dikes over the wet ash, and the existence of an unusual foundation layer consisting of sensitive slimes and silts. AECOM concluded that the failure on December 22, 2008, depended on all four factors, without them working in combination, the failure would have not likely occurred on this date. AECOM's root cause analysis discussed in detail the thin layer of slimes beneath the dikes and identified the thin, discontinuous, soft foundation layer (sensitive silt and slimes) as one of the most probable factors/root causes.

Marshall Miller's Conclusions
It is Marshall Miller's opinion that the scope of investigation, as presented by AECOM was sufficiently thorough for the root cause analysis and applied appropriate investigated methods, in-situ testing techniques, and sampling practices. Also, the fundamental conclusions of AECOM with regard to the four most probable root causes or factors contributing to the Kingston ash pond failure were technically plausible and reasonably supported by the study data. Marshall Miller concurs with AECOM that some or all of the four factors contributed significantly to the failure. However, Marshall Miller also notes that:

- Because the failure was not strictly associated with the "thin, weak slimes" layer, and more associated with the ash dike ("or fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

- AECOM was not able to recover and extrude undisturbed samples of the hydraulically placed ash for laboratory testing which adds uncertainty to AECOM's characterization of the hydraulically placed ash; and thus, the role of the loose, wet ash as a root cause of the failure cannot be discounted.

- Although the properties of the slime layer suggest it as a potential slippage surface based on mathematical modeling, it is not the only possible slippage surface. In fact, AECOM documented that slimes were not found in some locations, were not of consistent thickness, and had properties very close to those of the ash material itself.

- The characteristics of the loose, wet ash (hydraulically placed/sluiced ash) pose the wet ash as a probable root cause of equal or greater significance to the soft foundation soils (weak, sensitive silt and slimes foundation layer).

Other Marshall Miller Observations

As noted earlier in the report, AECOM's scope of work was limited to the identification of the likely initiator(s) ("root cause(s)") of the failure, which inherently encompasses consideration of potential failure modes, possible "initiators" or "triggers" of the onset of failure, and factors that contributed to its progression. This scope limitation resulted in Marshall Miller noting that the stated objectives of the AECOM root-cause analysis do not encompass the task of identifying necessary changes in design philosophy, design standards, construction documentation, inspection and instrumentation to prevent another Kingston-type failure. In addition, the root cause study and culminating report by AECOM defines the problem, but does not provide clear direction to TVA in the form of technical guidance for evaluating, designing, and constructing reliable containments for "wet" ash disposal now or in the future. Marshall Miller also concluded:

- Given what is known now about the ash material and the geologic conditions within the Kingston ash disposal facility before December 22, 2008, there was an unquantified probability of failure. Consequently, the sensitivity of the upstream-constructed containment dike system to changes to loading, loading rate, seepage regime,

sluiced ash behavior, and other circumstances must be appreciated to preclude another catastrophic failue as occurred on December 22, 2008.

- As discussed more thoroughly later in this report, as early as 1985, intrinsic problems related to the stability of the Kingston Dike C were mentioned, specifically in a TVA memorandum. This memorandum indicated that the calculated factor of safety was less than the minimum acceptable value and close monitoring was recommended to detect any potential signs of failure in lieu of changing TVA policies and procedures that would require that the ash pond be designed to the higher "dam safety" standard. No specific action by TVA appears to have been taken as per the reviewed documents.

- Had TVA included its ash ponds in the Dam Safety Program, discussed in December 1988 when TVA decided against this policy, protocol would have been established for performing customary geotechnical exploration, in-situ and laboratory testing, dike seepage and stability analyses, and adherence to the higher "dam" design standards, and the probability of identifying some or all of the conditions that led to the Kingston failure would have increased significantly.

- The design of the Kingston coal ash dredge cells should have included a thorough engineering evaluation of all potential failure modes.

- AECOM's study focused disproportionately on the significance of the thin, discontinuous, soft foundation layer (sensitive silts and slimes) as one of the most probable factors/root causes. Marshall Miller stated the significance of the "Fill Geometry" factor/root cause should be equally emphasized. This fill geometry refers to upstream-constructed dike configuration on sluiced ash foundation. In Marshall Miller's professional opinion, "Fill Geometry" is of equal or greater significance relative to the "Soft Foundation Soils" factor.

- AECOM's root cause study concludes, "*The failure on December 22, 2008 depended on all four factors [root causes], without them working in combination, the failure of Dredge Cell 2 would have not likely occurred on this date.*" In Marshall Miller's professional opinion, the suggestion that all four factors had to work in combination to cause the failure diminishes and disregards the risks that were posed by the upstream-constructed dike configuration and disposal procedures and the ever increasing height of Dredge Cell 2.

- Other factors evaluated by AECOM as probable root causes should be strongly considered by TVA and the power generation industry as a whole in evaluating the condition and structural integrity of ash disposal facilities. Each one of these factors is critical and should be closely evaluated for all of the existing TVA ash handling and disposal facilities. These concerns and findings could have a significant effect on the requirements and standards of care for facilities throughout the Fossil Plant industry.

- It would not be prudent to assume that, if the slimes layer observed in the failed section at Kingston does not exist at other plant sites, there is adequate stability of these structures. On the contrary, the information developed from the extensive studies conducted by both Stantec and AECOM indicates that there is a reasonable risk of other dike failures if changes are not made in the design construction, oversight, and operation of the wet ash disposal sites throughout TVA.

- If the ash ponds had been included in the Dam Safety Program, closer evaluation and a more sound "engineered" solution probably would have occurred pertaining to the 2003 leak at the Swan Pond road dike.

- TVA "designs" provide very little "room for error" which was evident at Kingston. It is considered solid engineering practice to design such facilities with features that provide a reasonable degree of redundancy or "second line of defense" in the event that one or more of the systems becomes inoperable. In Marshall Miller's opinion, it is important this design philosophy be applied to all of TVA's ash disposal facilities.

TVA'S ENTERPRISE RISK MANAGEMENT PROGRAM DID NOT ADEQUATELY ADDRESS KNOWN RISKS ASSOCIATED WITH ASH PONDS

Risk management underpins an agency's approach to achieving its objectives and provides crucial mechanisms for staff to identify and report key risks to senior management. An Enterprise Risk Management process is designed to identify and mitigate risks such as those associated with ash management. Successful implementation of a risk management program occurs when:

- Risk management is embedded in how the organization conducts business;

- The value of risk management is clearly understood by executive and line managers;
- The firm's risk tolerance is clearly articulated;
- Risks are systematically identified, assessed, and communicated;
- Decisions are made with due consideration to risk/return tradeoffs; and
- Risk adjusted performance metrics are specified and monitored.

Modern corporations operate to a certain extent based on their assessment of risks. The better the risk assessments of the company the better the company performs. Risks tolerance differs in every industry and in every company. Some companies have a very low risk tolerance, for example, for activities that could result in breeches of environmental compliance or public safety. A company's Enterprise Risk Management Program ideally identifies risks on what is commonly referred to as a "heat map" according to the likelihood of a risk occurring and then the severity of consequences if the risk event occurs. If the likelihood is high and the severity is high, the corporation typically devotes more resources to risk avoidance in that particular area. TVA's Enterprise Risk Management Program began in 1999, when TVA's Board of Directors issued a risk policy authorizing the creation of a Risk Management Committee, appointment of a Chief Risk Officer, and adoption of an enterprise-wide risk management approach.

The OIG reviewed the Enterprise Risk Management Program in both 2003 and 2008 and recommended various improvements to it. The 2008 review, done with the assistance of an external consultant with broad knowledge of risk management practices, found that TVA had made progress in risk identification and assessment since 2003 and that the commitment to risk management at the top of the agency was strong. However, the OIG assessment, published in September 2008, also found that the program needed to be driven further down into the organization.

We determined that risks associated with ash management were known internally as early as 1987. Despite this internal knowledge, we found no evidence that TVA's Enterprise Risk Management Program had identified ash management as a significant risk.[20] While TVA did not have a formal Enterprise Risk Management process during the 1987 through 1996

[20] The only risk related to ash identified by the Enterprise Risk Management Program, in March 2008, was the financial risk that ash ponds would be designated as hazardous waste facilities requiring liners and other remediation actions.

timeframe, it did have one at the time of the Kingston Spill and for several years prior.

In reviewing documentation, we found numerous memorandums dating from 1987 through 1996 where TVA internally discussed whether ash ponds should fall under the Dam Safety Program. TVA recognized that if dam safety guidelines were implemented, additional steps would need to be taken, such as closely reviewing the existing inspection procedures for compliance with dam safety requirements, performing additional stability analyses, adding monitoring instrumentation, and instigating a drilling and testing program. Some TVA managers and executives took the position that managing ash ponds under the Dam Safety Program was unnecessary for safety, and TVA was not technically required to do so. TVA ultimately did not place the ash ponds under the Dam Safety Program.

Below are some highlights from the memorandums we reviewed where placing TVA's ash ponds under its Dam Safety Program was discussed:

- In June 1987, the Manager of Policy, Planning, and Budget stated that, "Greater amounts of ash have resulted in expansions of ash ponds. In some instances the dikes that contain this water have become quite high with increasing risk and consequences of a breech. Because of the potential for harm to both surface and groundwater from the failure of a dike, greater attention and establishment of more specific inspection standards for these dikes should be examined."

- In response to the June 1987 memorandum, the Safety Office Coordinator prepared a memorandum stating: "(1) Many of these dikes should be classified as dam safety (possibly safety deficient) and inventoried into TVA's inventory as Ash Pond Dikes, and (2) TVA should bite the bullet and place them under the Dam Safety Office and begin a program similar to the present dam safety program."

- In 1988, the Manager of Dam Safety Program wrote, "It is my understanding that there may be as many as 17 ash ponds contained by earthen filled "dams" in the TVA system that may meet or exceed the technical definition provided by the guidelines." Yet in 1989, the Vice President of Power Engineering and Construction stated, "The potential for loss of life or significant property damage as a result of a failure at one of these facilities is minimal...Therefore, we can see no advantage to TVA in reassigning management control to the Dam Safety Program."

- In a 1988 draft memorandum, the Vice President of Power Engineering and Construction wrote, "Because of concerns about groundwater contamination, TVA is moving away from wet ash disposal techniques to dry stacking."

- In an undated memorandum, the Vice President of Fossil and Hydro Projects said for those dikes redefined as dams, "TVA will have to (1) perform additional stability analysis, (2) add instrumentation, ..., (3) calculate and document flooding criteria, (4) perform inspections at intervals no greater than 2 ½ years, and (5) prepare emergency notification procedures for each plant."

- In 1996, the TVA Manager of Fossil Engineering stated, "A previous internal agreement established that TVA does not consider the waste disposal area dikes hazardous as defined by this act. Therefore, we continue to manage them as pollution control facilities, not 'dams.'...In general, we would expect these inspections to meet dam safety inspection requirements; however, should these dikes be reclassified as 'dams,' we would need to closely review our inspection procedures for compliance. Also, should these dikes be reclassified to 'dams,' we would probably need to reanalyze our dike stability and in many cases, need to instigate a drilling and testing program before performing this analysis...We believe it would be in TVA's best interest to continue to treat the waste area dikes as pollution control facilities rather than as 'dams.'"

Since the September 2008 OIG assessment of TVA's Enterprise Risk Management Program, TVA has hired additional risk management personnel and restructured its program to, among other things, drive the program further down into the organization by starting the risk assessment process in the strategic business units. If TVA is able to do this effectively, it will increase the likelihood that it will surface and deal with issues such as the ash ponds that were known to various parties in TVA but not identified as part of the Enterprise Risk Management process.

THE CULTURE AT TVA'S FOSSIL FUEL PLANTS IMPACTED ASH MANAGEMENT

It's the Culture

Our review disclosed attitudes and conditions at TVA's fossil fuel plant that emanate from a culture that impacted the way TVA handled coal ash. We give some examples of that in this section that may seem anecdotal, but they are consistent with our observations about the culture in other parts of TVA as well. Over the last nine months, the OIG has conferred with the

TVA Board and TVA management about what we perceive to be systemic problems that have their genesis in the culture. While we recognize that there is no one culture at TVA and instead there are subcultures that vary from one organization to another within TVA, there are common themes we find antithetical to a high performance organization. While the culture at TVA's fossil fuel plants is not the cause of the Kingston Spill, the culture, in our view, is likely to be resistant to the kinds of reforms necessary to avoid other safety failures.

Corporate culture is defined as the combined beliefs, values, ethics, procedures, and atmosphere of an organization. The culture of an organization is often expressed as "the way we do things around here" and consists of largely unspoken values, norms and behaviors that become the natural way of doing things.[21] Over TVA's 75-year history, cultural traits have developed that if not identified and addressed can undermine the best policies and procedures. The importance of recognizing cultural limitations cannot be overemphasized.

This discussion of culture could be perceived to suggest that TVA employees are guilty of bad behavior. Culture, however, is more a product of management and leadership over successive generations than a product of a bottom up phenomenon. Changing or renewing corporate culture in order to achieve the organization's strategy is considered one of the major tasks of organization leadership and such change doesn't happen without focused leadership. We believe that TVA employees come to work every day to do a job, a good job. If their culture ("how we do things around here") harms the organization, that is a leadership problem.

TVA management is now implementing new policies and procedures to change the way TVA has handled coal ash. History suggests that the very best policies and procedures can be successfully resisted by a strong legacy culture. For TVA to be successful in avoiding another Kingston Spill, the culture must be accurately assessed, compliance with new policies and procedures must be faithfully measured with appropriate metrics, and employees must be educated to think differently about ash management than they have over several generations.

[21] This definition of corporate culture came from the BNET.com Business Dictionary, Corporate Culture: Definition and additional sources from BNET. BNET's Web site notes its Business Library provides unlimited access to one of the largest databases of white papers, Web casts, and case studies on the Web.

Corporate-wide safety programs fail when policies and procedures are not driven from the top of the organization to the bottom of the organization. That requires clear communication from leaders and crisp "zero-tolerance" from managers below them. The audits and investigations conducted by the OIG over the last ten years indicate repeat findings of noncompliance with policies and procedures. The challenge to drive compliance consistently through the organization is a difficult one that requires a new approach.

As we state in our recommendations section of this report, we believe TVA needs a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout TVA. This group should be tasked with identifying and addressing directly any underlying resistance not just to the new policies and procedures for coal ash management but resistance to TVA's policies and procedures across the enterprise. A change management task force of sorts should also: (1) devise a comprehensive plan to drive compliance; (2) establish appropriate metrics to measure accountability; and (3) review policies and procedures for consistency and relevancy.

History suggests that if TVA merely creates new policies and procedures to be implemented in the same fashion as before but within a new organizational box, the culture will eventually erode the effort. While a task force approach to compliance may seem drastic, the Kingston Spill demonstrates how ineffective programs can be if a legacy culture is not addressed.

Culture and Ash Management

During our review, we found that ash management at TVA reflected a culture that ash was unimportant. This resulted in significant weaknesses in ash management practices across TVA including: (1) a failure to implement recommended corrective actions that could have possibly prevented the Kingston Spill; (2) the lack of policies and procedures; (3) poor maintenance; (4) the lack of specialized training; (5) multiple organizational structure changes; (6) inadequate communication; and (7) a failure to follow engineering best practices.

While the weaknesses we identified clearly demonstrate cultural issues, interviews with current and former TVA employees lend further support to our view that ash was seen as unimportant. We interviewed plant personnel, engineering personnel, and management and heard several comments indicative of a culture resistant to treating ash management as much more than taking out the garbage. For example:

- One member of management stated, "Ponds have always been the back end of the plant. It is the same way at other utilities," indicating that ponds are not an area of primary focus for utilities.

- A former member of management believed, "Being sent to Yard Operations is like being sent to Siberia," suggesting the yards were not considered a place of high importance.

- Another employee said, "The further away from the plant you got the less management seemed to care," conveying the ponds got little attention because they were away from the plant and not directly related to power production.

- A TVA engineer said TVA had always stacked ash higher at KIF so it must be okay. He went on to say that if something worked in the past, TVA will keep on doing it and that TVA had a cheap solution to ash storage by stacking higher so that is what they did.

- After being questioned about a current ash disposal project by Marshall Miller, a TVA engineer was critical of Marshall Miller consultants and stated they were trying to turn a landfill into "rocket science." This is clearly reflective of a culture resistant to a professional engineering standard of care.

TVA Lacked Policies and Procedures for Ash Management
When asked by the OIG, TVA personnel were unable to provide any policies and procedures dealing with the storing, handling, and maintaining of ash and ash facilities. TVA personnel said they follow the state approved operations permit for each plant, but had no policies and procedures regarding how to do so. Without policies and procedures, it is unclear who is responsible for specific tasks, how to address certain problems when they arise, and how to ensure proper communication occurs. When discussed with the CEO, he agreed that without policies and procedures needed actions often do not occur.

Ash Storage Facilities were Poorly Maintained
Through review of inspection results and visits to seven sites[22] by Marshall Miller, we found that reported maintenance issues were often not addressed. TVA Engineering conducts annual inspections of each of TVA's ash storage areas. These inspections are documented in the annual inspection report for each fossil plant. Our review of all such

[22] Marshall Miller visited and assessed conditions at the following seven sites: Bull Run Fossil Plant, Cumberland Fossil Plant, Johnsonville Fossil Plant, John Sevier Fossil Plant, Kingston Fossil Plant, Paradise Fossil Plant, and Widows Creek Fossil Plant.

available reports for the last five years for each of TVA's plants found that legacy problems existed at all of TVA's fossil plants. Legacy problems are problems documented in consecutive reports without being addressed by TVA. We found the following legacy problems in reviewing the inspection reports:

- Erosion – which can cause dike instability because of loss of structural cover;
- Seepage – which can cause internal dike erosion and dike instability;
- Overgrown vegetation – which can make it difficult to conduct a thorough inspection and to identify suspect dike changes, such as cracks, bulging, and seepage outbreaks;
- Sparse vegetation – which can allow erosion to occur and expand more rapidly;
- Tree growth on dikes – which can mask seepage issues and weaken the structural integrity of the dike;
- Standing water – which can cause the soil and ash to become saturated and weaken the dike; and
- Piping issues – joint and seepage failures and displaced materials at outlet piping.

TVA Engineering reported these issues repeatedly, but few corrective actions were taken. There were certain instances where corrective actions created additional problems. For example, in one instance TVA cut down trees to address a vegetation issue, but did not remove the roots; as a result, depressions developed on the dikes.

In addition, Marshall Miller's work at seven sites confirmed what we found in reviewing the annual inspection reports. They noted general maintenance issues at each facility visited. Legacy maintenance issues identified by Marshall Miller include:

- Heavily overgrown vegetation.
- Trees on dikes.
- Indications of six shallow depressions of varying size and depth in the western slope of the embankment at Johnsonville Fossil Plant (JOF).

Some of these depressions have been documented by TVA during its yearly inspections; however, it appears they were not addressed until very recently. Specifically, TVA's inspection reports for the previous three-year period stated that initially one, then four, and finally six depressions were observed to be re-occurring on the western side of the embankment. While the condition worsened from year to year, no actions were taken to address the problem (Stantec has performed an investigation of the depressions and determined that no additional actions are needed at this time).

- The presence of multiple uncontrolled seepage points or seepage outbreaks is one of the main problems at the JOF Active Ash Impoundment Area. These apparently have existed for many years. They have been documented by TVA representatives and/or their consultants in various inspection reports; however, no actions have been taken to resolve the conditions.

In our discussions with the Senior Vice President, Fossil Operations Support, he concurred that maintenance has been a big problem in the past. For example, he noted that it had been a common practice to mow the facilities only twice a year, which made visual inspections difficult if not impossible. He further noted that TVA is working to address this issue by increasing the frequency of mowings, removing trees from dikes, improving drainage, and other steps as needed to improve maintenance.

Ash Storage Inspectors at TVA Lacked Training
Through interviews conducted at fossil plants, we found that there is no formalized training for the personnel who inspect the dikes. The daily visual inspections are generally conducted by plant personnel and annual inspections are conducted by engineering personnel with no specialized training for dike inspections. Management concurred that no specialized training for inspectors of ash pond dikes had been provided. In our opinion, standardized training would result in several significant benefits, such as equipping inspectors to:

- Recognize maintenance issues early;
- Properly assess the significance of issues identified;
- Identify changing conditions; and
- Properly communicate issues identified.

Organizational Changes Hampered Accountability
Through the years the management of the ash ponds has undergone significant changes. In 1999, Yard Operations, which had responsibility for the ash ponds, was moved from the plants' control to the Heavy

Equipment Division (HED). The plants had numerous efficiency issues, and management did not believe the plants could address those issues as well as the problems that existed with Yard Operations and the ash ponds.

In 2006, TVA's CEO made the decision to move the ash pond management back under the control of the plants. However, the CEO said that he had concerns about accountability because of all the organizational changes that occurred in this area over the years. According to the COO, TVA recognized this problem and has reorganized the ash management function to, among other things, promote accountability. Prior to the spill in 2008, Combustion By-Products moved from the Fossil Operations Region 2 group to the Operations Support group.

Communication Among Organizations was Inadequate

Through interviews and document reviews, we found that fragmented organizational responsibilities for ash management created silos that contributed to inadequate communication. One individual stated plant management was not informed of problems with the ash ponds. The problem was further demonstrated by a TDEC representative who stated, "It seemed the plant management, the environment group, and other groups at TVA were not always communicating." The TDEC representative stated that his questions often had to be directed to different groups. He heard from TVA personnel that they could not get management to recognize the urgency of ash management at the plants. Another communication issue was found in a plant's summary of the FY 2008 Inspection Report. An engineer stated, "An internal dredge cell was constructed inside of the bottom ash pond without consultation or input from Engineering. It was in such poor condition that Engineering recommended against its use until modifications were made. (Subsequent to the inspection, modifications were made and the dredge cell was used successfully.)" The fact that modifications were made to an ash facility without obtaining input from engineering demonstrates a lack of communication, as well as a lack of appreciation of the importance of having professional engineering input into dike modifications.

During a site visit to one of the plants, Marshall Miller identified uncompacted and/or poorly compacted gravel that had been placed around the perimeter of the fly ash impoundment. In Marshall Miller's opinion, the condition of the stone layer indicated there had not been any engineering or field oversight/quality control to ensure it was properly placed and compacted. Since the proper base was not established and the gravel was poorly compacted, it would not achieve its intended purpose and was a waste of TVA money. TVA management

acknowledged that they acted quickly to address complaints about ruts and holes due to increased traffic in the area and did not obtain engineering input.

TVA Did Not Follow Engineering Best Practices

We found that TVA did not follow engineering best practices with respect to ash ponds. According to Marshall Miller, dikes such as the failed one at Kingston that contain hydraulically placed materials with the potential to impound water should be treated as dams. Compared to a dam constructed across a valley or hollow, expansive dike systems for coal ash storage can present greater uncertainties relative to the native foundation, hydraulically placed materials, and dike/embankment materials. Marshall Miller observed that treating ash storage facilities as dams would have significant implications to TVA's (1) standards for designing the facilities, (2) construction documentation and inspection, and (3) instrumentation and monitoring activities (for more detailed information see Appendix C).

Moreover, during the course of our review, we discovered a TVA design guide for performing static slope stability analyses that was last updated in June of 1981. The design guide covered key areas such as: (1) field and laboratory testing, (2) evaluating soil characteristics, (3) facility loading characteristics and required factors of safety, (4) methods of analysis, and (5) slope stabilization techniques. Our consultant, Marshall Miller, reviewed this design guide and commented that it represented good engineering and design standard as of 1981. Unfortunately, TVA has not updated the design guide to reflect engineering and design standards as they evolved since 1981.

In practice, we saw this failure to follow engineering best practices manifest itself in several ways. For example:

- TVA did not create "as-built" or "record" drawings, which would document construction of the facilities as they were built including any deviations that might occur between actual construction and the engineered design, permit, or construction drawings. According to TVA engineers, this has been a problem but recent improvements have been made in regards to placing "as-built" drawings on the TVA drawing system.

- TVA did not always have an engineer on-site to perform Construction Quality Assurance/Construction Quality Control (CQA/CQC) while modifications or construction of ash storage facilities occurred. The CQA/CQC function helps to ensure that the facilities are designed to current engineering, agency, and regulatory standards and remain in accordance with good engineering practice. Furthermore, this practice

ensures that these facilities are constructed in accordance with approved engineering design plans, and that the as-constructed conditions are properly documented for future reference.

- TVA did not require construction drawings to be stamped by the Professional Engineer (P.E.) of record. A P.E. stamped drawing would identify the design engineer-of-record and their firm, which would reduce the risk of using an incorrect version of a drawing, provide an appropriate technical contact for resolving ambiguities in design and construction documents, performance issues, and other problems that might arise, and define the primary entities that are accountable for the design. Management stated they will evaluate the need to have construction drawings stamped in the future.

As we point out above, these conditions indicate a pervasive legacy culture that impacted coal ash management. A new approach as suggested in our recommendations section is warranted.

TVA HAS RECENTLY ACTED TO ADDRESS CERTAIN ASH MANAGEMENT WEAKNESSES

As we have previously noted, since the Kingston Spill TVA management has begun to reassess its ash management program and has taken several actions to improve ash management across the agency. These actions include (1) organizational changes to address management and accountability issues, (2) changes designed to change the corporate culture which had deemphasized the importance of ash management, and (3) steps to assess ash storage facilities against dam safety guidelines with the goal of complying with dam safety guidelines where possible. Actions taken to-date include:

- TVA recognized there are too many business units involved in ash pond design, maintenance, modification, and operations and has taken steps to improve the organizational structure. On April 24, 2009, the COO announced that TVA will be establishing a new Coal Combustion Products Management Division (CCPMD). According to the COO, "This will allow us to bundle all coal-combustion products, gypsum-management activities and other ponds into one group to develop and implement a consistent fleet strategy for these operations." The Senior Vice President (SVP) of Fossil Operations Support said TVA has reorganized the fossil division for better management. He said one person has been designated Vice President of Engineering and will be responsible for the contractor assessing and designing changes for all TVA ash facilities, all the capital projects to convert the wet ponds to

dry stacks (including gypsum and ash), closure of the ponds, new bottom ash ponds, and issues identified during inspections. He further explained that another position has been given responsibility for the day-to-day operations, by-product sales, maintenance, and assigning dedicated supervisors for the daily operation of the ponds. The maintenance program will also include any ponds which have the potential for an environmental release. The COO stated the organizational changes were made to enhance accountability, transparency, and communication.

- TVA also recognized that the mindset and culture regarding ash ponds needed changing and more emphasis needs to be placed on ash management. For example, the SVP of Fossil Operations Support was recently given the authority to shut a plant down if he finds significant issues with ash management. In addition, the organizational changes to enhance the authority and accountability of those responsible for ash management described above, along with the memory of the KIF spill, underscores the importance of the proper management of ash at TVA.

- In addition, TVA has moved toward managing the ash ponds under dam safety engineering, construction, and operation, inspection and maintenance guidelines. According to the COO, TVA is now taking steps to implement a program for ash facility management that is in compliance with dam safety guidelines. He went on to say while TVA plans for ash storage facilities to meet dam safety requirements, they acknowledge that some facilities may not be able to meet all the requirements because of their original designs and construction. TVA hired Stantec to assess the condition of its ash ponds and to help restructure ash management. For example, TVA does not believe it can meet the recent seismic requirements for the dam safety standards at certain facilities. In addition, the Stantec assessments may reveal that certain other dam safety standards are unachievable. Stantec stated that TVA had not previously followed the dam safety guidelines for their ash ponds because Tennessee regulators exempted TVA, Alabama does not have clear dam safety guidelines, and it was unclear to Stantec if TVA was granted an exception to the Kentucky dam safety guidelines.

RECOMMENDATIONS

In addition to the management actions noted above, we recommend the CEO, in consultation with the Board of Directors, where appropriate:

- Commission a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout TVA and measuring positive changes in the culture that effects ash management and other TVA programs.

- Assess the culture of the fossil fuels group to determine what changes need to be made, if any, to ensure the support for sound policies and procedures related to ash management.

- Assess the management practices of TVA for ash management to determine whether those practices contributed to the failure of the dike at Kingston.

- Complete the assessments of TVA ash storage facilities and determine which ones are at risk of failure. The determination should be, as suggested by Marshall Miller, based on whether any of the four conditions contributing to the failure at Kingston exist sufficiently to pose a significant risk of failure. The determination should not be limited to just looking for the existence of the combination of all four contributing conditions found at Kingston.

- Develop policies and procedures for the storing, handling, and maintaining of ash and ash disposal facilities.

- Continue the efforts to drive the Enterprise Risk Management Program further down into the organization to increase the future likelihood that known risks will be identified and addressed.

OBJECTIVE, SCOPE, AND METHODOLOGY

The objectives of our overall review are to determine (1) the causes of the spill, (2) the adequacy of TVA's response to the spill, and (3) what TVA can do to assure the public that a similar spill will not occur again at this or any other TVA plant. The purpose of this inspection is to (1) provide an independent peer review of AECOM's root cause analysis and (2) review TVA's ash management for weaknesses. To achieve the objectives of this report, we:

- Hired Marshall Miller & Associates (Marshall Miller) to perform an independent peer review of TVA's root cause analysis and provide other observations about coal ash management at TVA. Marshall Miller has expertise in coal ash and other waste materials, containment design for hydraulically placed or sluiced ash and mine tailings, earthen and mine waste dams and, more generally, materials science and geotechnical engineering. Marshall Miller's peer review of AECOM's root cause analysis is presented in the attached Appendix B, and its other observations on coal ash management at TVA are in Appendix C.

- Conducted interviews with selected TVA management, engineering personnel, plant personnel, and consultants.

- Obtained and reviewed the last five years of available annual inspection reports of TVA waste disposal facilities to identify legacy issues at the fossil plants.

- Performed walkdowns, along with Marshall Miller, of seven fossil sites.

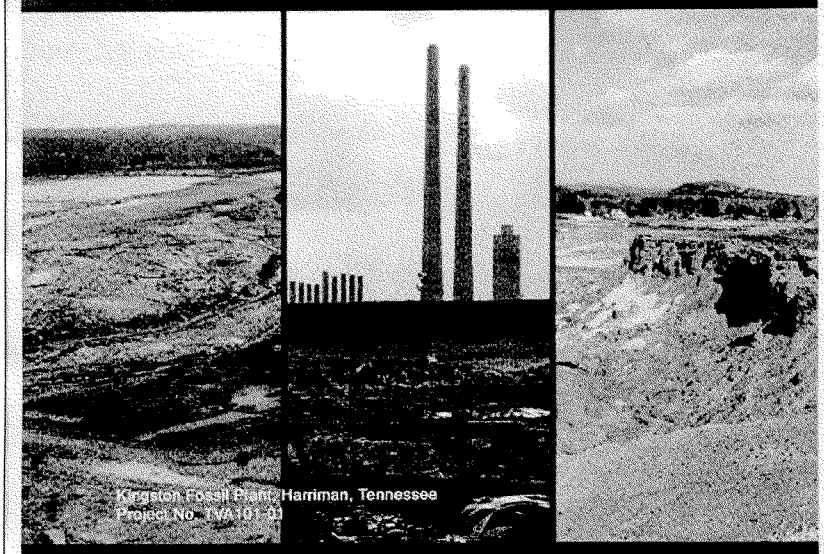
- Obtained and reviewed documentation pertaining to the ash storage at TVA (e.g., memorandums, quarterly inspection reports, etc.)

- Attended key TVA meetings, which included amongst others TVA's consultants.

This review was conducted in accordance with the Quality Standards for Inspections.

Report

Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008



Prepared for:

July 2009

TVA Office of the Inspector General
Knoxville, Tennessee

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Item 1: TITLE PAGE

Title of Report

Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008

Project Location

The project site is located in Harriman, Roane County, Tennessee, and is situated on a peninsula formed by the confluence of the Emory River and the Clinch River.

Qualified Persons

William S. Almes, P.E.
Project Manager
Senior Engineer & Director of Geotechnical Services
Marshall Miller & Associates, Inc.

EDMUNDO JOSE LAPORTE REGISTERED ENGINEER No. 111670 STATE OF TENNESSEE 07/09/09

Edmundo Laporte, P.E.
Senior Project Engineer
Marshall Miller & Associates, Inc.

Christopher J. Lewis, P.E.
Principal Engineer
D'Appolonia, Engineering Division of Ground Technology, Inc.

Effective Date of Report

July 9, 2009

MARSHALL MILLER & ASSOCIATES

Item 2: Table of Contents

List of Figures

Note: Figures 1 through 5 have been included within this report for reference only. All figures were obtained from the AECOM report entitled "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" dated June 25, 2009.

Item 3: INTRODUCTION AND BACKGROUND

The **Tennessee Valley Authority (*TVA*) Office of Inspector General (*OIG*)** engaged **Marshall Miller & Associates, Inc. (*MM&A*)** to conduct a peer review of the Root Cause Analysis (*RCA*) prepared by **AECOM Technologies Corporation (*AECOM*)** relating to the ash dredge cell failure which occurred at the TVA Kingston Fossil Plant (*Kingston*) near Harriman, Tennessee, on December 22, 2008. On June 25, 2009, AECOM publicized the results of its comprehensive six-month study entitled "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008." According to AECOM, the root cause of the failure was a complex set of conditions, including a long-evolving combination of the high water content of the wet ash, the increasing height of ash, the construction of the sloping dikes over the wet ash, and the existence of an unusual foundation layer consisting of sensitive slimes and silts.

It is MM&A's understanding that shortly after 12:00 a.m. Eastern Standard Time (*EST*) on December 22, 2008, the north and central portions of Dredge Cell 2 of the ash disposal site failed, and an estimated 5.4 million cubic yards of ash were released in a progressive sequence of flow slides over a period of one to two hours. The ash spill extended outside of the Dredge Cell 2, covering approximately 300 acres of the Swan Creek flood plain and surrounding acreage. While there was no loss of life, 3 homes were destroyed and 23 homes were damaged, electrical power was disrupted, a natural gas line in a neighborhood located adjacent to the plant was ruptured, and the ash covered a railway and road in the area. The flow slide extended beyond the limits of the original ash pond, referred to as Dike C. AECOM described the uneven limits of the flow slide as extending (1) northward approximately 3,200 feet up Slough No. 2 and against the flow of the Emory River Channel; (2) more than 1,600 feet southward toward the Emory River; and (3) nearly 1,000 feet up Slough No. 3, a side channel to the reservoir. The ash disposal Cell 2 had been permitted by the **Tennessee Department of Environment and Conservation (*TDEC*)** as a Class II Solid Waste Landfill under State regulations.

MM&A initially visited the Kingston facility on February 4, 2009, and met with various representatives of the OIG, TVA, and AECOM, among others, during the course of the engagement. Subsequently, MM&A was provided access to various documents including

engineering design drawings, photographs, aerial maps and other documents which were reviewed in the context of the engagement.

Item 4: MM&A PROJECT TEAM

MM&A, an employee-owned Engineering News-Record Magazine (*ENR*) Top 500 company, began offering geologic services to the mining industry in 1975 and for 33 years has provided a full range of related services to the mining, utility, financial, governmental, and legal industries. Today, MM&A employs nearly 200 engineers, geologists, scientists and other professionals working from regional offices in ten states.

It is noteworthy that members of MM&A's Project Team have been intimately involved with the development of the two engineering design manuals prepared by the **Mine Safety and Health Administration (*MSHA*)**, which specifically address the procedures that should be followed for designing and operating coal refuse impoundments and embankments. The first manual was published in 1975, and an updated version is scheduled to be released in 2009. Although these manuals were written to address the design and operation of coal refuse disposal facilities, the key chapters, which include material characterization, hazard classification, planning, staging, foundation considerations, surface drainage and storm water control, instrumentation monitoring, geotechnical engineering and design, seismic hazard assessment, seismic stability and deformation, environmental considerations, and emergency action plans, are directly applicable to the disposal of fly ash and bottom ash materials

MM&A has also been involved with forensic studies of major waste impoundments that have experienced uncontrolled releases of fine slurry, as well as slope instability within the embankment portions of both coal ash embankments and impoundments and coarse coal refuse dams.

The MM&A Project Team is comprised of the following professionals:

- Mr. Peter Lawson – Executive Vice President & Principal-in-Charge
- Mr. William S. Almes, P.E. – Director of Geotechnical Services & Project Manager for TVA OIG
- Mr. Edmundo Laporte, P.E. – Senior Engineer
- Mr. William M. Lupi, P.E. – Project Engineer

- Mr. John E. Feddock, P.E. – Senior Vice President & Senior Peer Review Team Member
- Mr. Richard G. Almes, P.E. – Principal Geotechnical Engineer & Senior Peer Review Team Member
- Mr. Christopher J. Lewis P. E. – Principal Geotechnical Engineer & Senior Peer Review Team Member[1]

[1] Christopher J. Lewis, P.E. is a Geotechnical Subconsultant of MM&A and is employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

Item 5: SCOPE OF WORK & BACKGROUND

5.1. SCOPE OF WORK

MM&A was engaged to provide technical support and independent opinion to the TVA OIG in its review and documentation of the failure of Dredge Cell 2. Specifically, MM&A was to perform an independent peer review of AECOM's RCA report as contracted by TVA.

MM&A has completed a peer review of the final version of the AECOM RCA. Notably, MM&A did not conduct a parallel investigation to AECOM's. MM&A's professional opinions are based principally on the review of various documents regarding Dredge Cell 2, a meeting with AECOM personnel at their Vernon Hills, Illinois, office location on June 2, 2009, briefings provided by AECOM during presentation and conference call meetings, and a review of the final RCA report dated June 25, 2009.

5.2. BACKGROUND

AECOM was retained by the TVA **Office of General Counsel (*OGC*)** to perform an RCA investigation of the ash Dredge Cell 2 failure, after AECOM conducted its initial visit to the site on January 8, 2009. According to AECOM, its scope of work was limited to the identification of the likely initiator(s) ("root cause(s)") of the failure, which, according to AECOM, inherently encompasses consideration of potential failure modes, possible "initiators" or "triggers" of the onset of failure, and factors that contributed to its progression or propagation.

AECOM executed a consulting agreement with the OGC on January 16, 2009, and commenced a data review phase shortly thereafter. Simultaneously, AECOM started a field exploration campaign, which ended on April 3, 2009. The field exploration program included the following activities:

- Completed 147 sampling borings
- Performed 59 standard penetration test borings
  - 8 of the 59 borings included rock coring and 25 of the 59 borings included slope inclinometer installations
- Prepared 21 piezometer locations and installed 54 piezometers
- Completed 48 vane shear/2" Shelby tube test borings

- Completed 40 Osterberg/Shelby tube sampling holes
- Completed 87 cone penetrometer CPTu tests
- Drilled and installed cross-hole geophysical test borings for **Stantec Inc. (*Stantec*)**, a subcontractor for TVA
- Located, surveyed, and logged identifiable relics
- Surveyed monuments, spillway, cell tower, outlet piping, etc.
- Observed two test trenches for location of outfall piping

As field samples and observations became available, AECOM started the laboratory testing and analytical phases of the project, which MM&A understands were completed during the first week of June 2009. AECOM performed multiple engineering analyses of the data obtained from site surveys and laboratory test results, while also undertaking an extensive compilation and review of documents from TVA's archives. The purpose of the laboratory testing program was to characterize the native soils and non-native site materials and to determine the geotechnical and mechanical properties of the soils and materials. In this manner, AECOM could analyze the soils' respective behavior and postulate the conditions prevailing in and below Dredge Cell 2 and Dike C prior to the failure on December 22, 2008.

It is MM&A's opinion that the scope of the investigation, as presented by AECOM, was sufficiently thorough for the RCA and applied appropriate investigative methods, in-situ testing techniques, and sampling practices. MM&A also believes that the laboratory geotechnical testing program was sufficiently thorough and applied appropriate and complementary suites of tests to characterize the native soils and non-native site materials (e.g., ash and slimes) in the primary areas of interest for the RCA.

Item 6: General Background on Historical Ash Disposal Practices

AECOM documented the history of development of fly ash disposal at Kingston, including the depositional and construction history of Dredge Cell 2 and of Dike C surrounding Dredge Cell 2 (See *Section 1.2* of the AECOM's RCA report dated June 25, 2009). Several important factors are observed from this history:

- The ash storage facility was built over portions of the former Swan Pond Creek flood plain. Clayey sediments found below Dike C and Dredge Cell 2 are "lacustrine," a term which refers to sediments deposited in lake environments. The type of sediment deposited in lakes can vary widely and locally depends upon the size of the lake, the climate, and the nature of the surrounding soils and environment.

- Prior to the construction of the initial ash containment dike, fly ash from the plant was sluiced directly into the Watts Bar Reservoir.

- In 1958, Dike C was completed creating the Ash Pond.

- Since the passage of the Clean Water Act in 1972, many industries in the United States, including the power industry, implemented new waste handling and disposal practices in an effort to prevent pollution of surface water and groundwater features. As a result of the operational changes, containment dikes for the ash disposal ponds were required. The upstream construction method, as depicted in **Figure 1**, consists of raising the crest of the impounding dike by constructing each successive dike, or stage, above previously placed/sluiced ash, which then becomes the foundation material.

- While employing the upstream construction method during the vertical expansion of the existing dredge pond, TVA's use of this practice at the site resulted in the Dredge Cell 2 having a series of ash dikes built with 3H:1V slopes and 15-foot wide benches founded on 35 to 40 feet of hydraulically placed or sluiced ash, with a 200-foot setback from the original Perimeter Dike C. The ash used for dike construction was

dredged from an adjacent ash collection / settling pond which was allowed to dewater over time.

- As the height of the dikes was increased, the dredge cell footprint area decreased as new lifts of material were placed. Consequently, more height was necessary to provide adequate storage for the same annual production of ash at the fossil plant. This process increased the total load and rate of loading imposed on the sluiced ash.

- Samples of the sluiced ash indicate that it has a high void ratio and does not show signs of consolidation or densification under the weight of new ash placed over older ash. As a result, the wet ash remains very loose and susceptible to liquefaction under rapid loading or rapid displacement.

- Laboratory test results also indicate that the wet ash is prone to experience static liquefaction due to its highly sensitive structure, which shows a rapid decrease in its shear strength when it changes from a drained to an undrained behavior.

The conclusion from these observations, and from the testing performed by AECOM, is that the depositional sequence and construction methods employed by TVA were confirmed by the exploration and testing program.

Item 7: Field Observations to Understand Direction of Movement and Failure Sequence

MM&A reviewed results of the analyses performed by AECOM to determine the direction of movement and inferred failure sequence. This was partly based on correlation of the final resting place of various relics observed on-site with their estimated position in the original dike configuration. It is MM&A's opinion that the methodology used by AECOM to determine the direction of movement is sound and, according to the information presented in AECOM's final RCA report, gives reasonable support to AECOM's generalized potential failure sequence.

7.1. Assessment of Key As-Built Condition Versus Design Configuration

7.1.1. Test Trench Exploration

As part of its RCA, AECOM excavated a test trench in one of the unfailed dikes in order to achieve the following goals:

1. Confirm the upstream dike construction geometry.
2. Compare the as-built conditions to TVA design drawings.
3. Determine whether the slip-film woven geotextile fabric indicated in the design documents was present under the base of the dikes.
4. Confirm the configuration of the dike drainage system.
5. Check the degree of compaction in the dikes.
6. Estimate fly ash and bottom ash proportions in the dike.

7.1.2. Findings

The main findings of the test trench exploration were:

1. There was no presence of a slip-film woven geotextile fabric layer beneath Dikes C1 through D2, as specified in the original TVA design drawings[2].

2 In accordance with the original design specifications prepared by TVA, a slip-film woven geotextile layer was required to be installed at these locations. The intent of adding this layer of geosynthetic material is unknown at this time. If the intended function of the material was to promote horizontal drainage between upper and lower dikes, other nonwoven materials should have been considered by TVA. Improper specification and use of geosynthetic materials can also promote weaker interface friction scenarios (since some woven geotextiles tend to exhibit a more "slick" surface than non-woven geotextiles) additional slope stability issues could occur.

APPENDIX B
Page 13 of 25

2. The dike heel drains were located, and it was confirmed that they were functional and built in accordance with the original plans. The drain pipes were oval but were not crushed.
3. No evidence of piping[3], plugging of pipes, or drainage gravel enveloped in filter fabric (nonwoven geotextile) was observed in the trench.
4. The majority of the dikes were constructed of fly ash, with occasional layers of bottom ash evident.
5. The construction of the dikes generally matched the design cross-section established by TVA.
6. It was found that mechanically placed ash, generally denser than sluiced ash, was disposed in the dikes.

[3] Internal erosion of the dike materials

Item 8: POTENTIAL FAILURE MODES, "TRIGGERS," AND MOST PROBABLE FACTORS/ROOT CAUSES OF FAILURE

In simplistic terms, the failure of Dredge Cell 2 and Dike C was the result of the hydraulically placed/sluiced ash assuming undrained behavior resembling a liquid and flowing into the Swan Creek flood plain and surrounding acreage. A technical review of the fly ash material identified several factors that indicate the conversion from a stable to unstable condition, which occurs rapidly as a result of the material's placement into undrained shear failure. In a technical letter report dated June 25, 2009, prepared for Mr. Ralph E. Rodgers, Assistant General Counsel for TVA, Dr. Gonzalo Castro, a Geotechnical Consultant from Lexington, Massachusetts, presented his conclusions regarding AECOM's analyses of the failure at Kingston. Castro succinctly explains the physical conversion from stable (drained) strength to the substantially lower undrained strength of the ash material[4]. The physical process involved in the liquefaction conversion is well documented in the literature for soils or materials with properties similar to the ash analyzed and tested by AECOM. Castro further observes that "Liquefaction caused by non-seismic triggering is referred to as static liquefaction… and caused by a) slippage elsewhere in the soil [ash] mass… b) an increase in the rate of loading… and c) local relatively rapid erosion at the toe of slopes…"[5] AECOM concludes that increases in the rate of loading and localized failure at the toe of slopes or other surface/outslope areas are lesser possibilities of triggering the failure that occurred.

In the course of its analysis, AECOM identified the following probable root causes of the Kingston ash pond failure:

1. Fill geometry (upstream-constructed dike configuration on sluiced ash foundation);
2. Increased fill rates (increased loads and loading rates due to higher fill levels and shrinking footprint);
3. Soft foundation soils (weak, sensitive silt and slimes foundation layer); and
4. Loose, wet ash (hydraulically placed/sluiced ash).

[4] Dr. Gonzalo Castro, Geotechnical Consultant, to Mr. Ralph E. Rodgers, TVA, June 25, 2009, Page 3.
[5] Ibid, Page 4

AECOM discussed the thin layer of slimes beneath the dikes of Dredge Cell 2, per item 3 above, which was discovered during its subsurface investigation (see **Figure 2**). Slimes do not exist beneath Dike C. Although the properties of this slime layer suggest it as a potential slippage surface based upon mathematical modeling, it is MM&A's opinion that it is not the only possible slippage surface. AECOM documented that slimes were not found in some locations, were not of consistent thickness, and had properties very close to those of the ash material itself.

The characteristics of the loose, wet ash, such as the rounded particle shape, weakly fused and loose particle structure, sensitivity, consistently high void ratios with increasing depth (lack of consolidation behavior), along with the contractive undrained behavior and very low undrained steady-state shear strength evidenced in the laboratory tests, pose the wet ash as a probable root cause in the failure of Dredge Cell 2. AECOM demonstrated three stages of the progressive failure, and these are included as **Figures 3, 4,** and **5**.

AECOM described the high sensitivity of the sluiced ash in very specific terms when it stated in *Section 1.8* of its RCA report: "Undrained behavior in the metastable ash requires less than 0.5% shear strain to reach peak strengths in both triaxial compression and extension tests. If cell loading exceeds the peak drained shear strength the available strength decreases rapidly towards an undrained steady state shear strength which may be as low as 100 psf."

It is MM&A's professional opinion that AECOM correctly identified the more probable root causes of the Kingston failure. MM&A concurs with AECOM that some or all of these four factors discussed contributed significantly to the failure. MM&A concludes that because the failure was not strictly associated with the "thin, weak slimes" layer, and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

Item 9: CONCLUSION AND OBSERVATIONS

The following outlines MM&A's conclusions and observations based on its review of AECOM's June 25, 2009 RCA report, as well as its review of various documents regarding Dredge Cell 2, a meeting with AECOM personnel at their Vernon Hills, IL office location on June 2, 2009, and briefings provided by AECOM during presentation and conference call meetings. In summary, MM&A found the following with regard to the RCA performed by AECOM:

1. The scope of the RCA, as presented by AECOM, was sufficiently thorough for the RCA, and AECOM applied appropriate methodologies, investigative methods, in-situ testing techniques, and sampling practices.
2. The laboratory geotechnical testing program was sufficiently thorough and applied appropriate and complementary suites of tests to characterize the native soils and non-native site materials (e.g., ash and slimes) in the primary areas of interest for the RCA. However, MM&A understands that AECOM was not able to recover and extrude undisturbed samples of the hydraulically placed ash for laboratory testing. This situation adds uncertainty to AECOM's characterization of the hydraulically placed ash at Kingston; thus, the role of the loose, wet ash as a root cause of the failure can not be discounted.
3. AECOM discussed the thin layer of slimes beneath the dikes of Dredge Cell 2, which was discovered during its subsurface investigation. Slimes do not exist beneath Dike C. Although the properties of this slime layer suggest it as a potential slippage surface based upon mathematical modeling, it is not the only possible slippage surface. AECOM documented (*Sections 1.3.4.2* and *1.7.11* of the RCA report dated June 25, 2009) that slimes were not found in some locations, were not of consistent thickness, and had properties very close to those of the ash material itself.
4. The characteristics of the loose, wet ash (hydraulically placed/sluiced ash), such as the rounded particle shape, weakly fused and loose particle structure, sensitivity, consistently high void ratios with increasing depth (lack of consolidation behavior), along with the contractive undrained behavior and very low undrained steady-state shear strength evidenced in the laboratory tests, pose the wet ash as a probable root cause of equal or greater significance to the soft foundation soils (weak, sensitive silt and slimes foundation layer).
5. The fundamental conclusions of AECOM's RCA with regard to the four most probable root causes or factors contributing to the Kingston ash pond failure are technically plausible and reasonably supported by the study data. MM&A concurs with AECOM that some or all of these four factors discussed contributed significantly to the failure.

6. MM&A concludes that, because the failure was not strictly associated with the "thin, weak slimes" layer and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

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Item 10: CLOSING

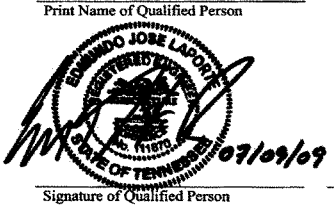
In preparing this report, the professional services of MM&A have been utilized, findings obtained, and conclusions made in accordance with generally accepted engineering principles and practices. MM&A reserves the right to amend and supplement this report based on new or additional information that might be obtained or become known. If OIG, TVA, TVA's consultants, or others discover additional information pertinent to the Kingston ash pond failure or related studies, MM&A requests the opportunity to review the information for significance relative to MM&A's findings and conclusions as presented herein.

ITEM 11: DATE AND SIGNATURE PAGE

The effective date of this Summary Report is July 9, 2009.

Signature of Qualified Person — July 9, 2009 (Date of Signing)

William S. Almes, P.E.
Print Name of Qualified Person



Signature of Qualified Person — July 9, 2009 (Date of Signing)

Edmundo Laporte, P.E.
Print Name of Qualified Person

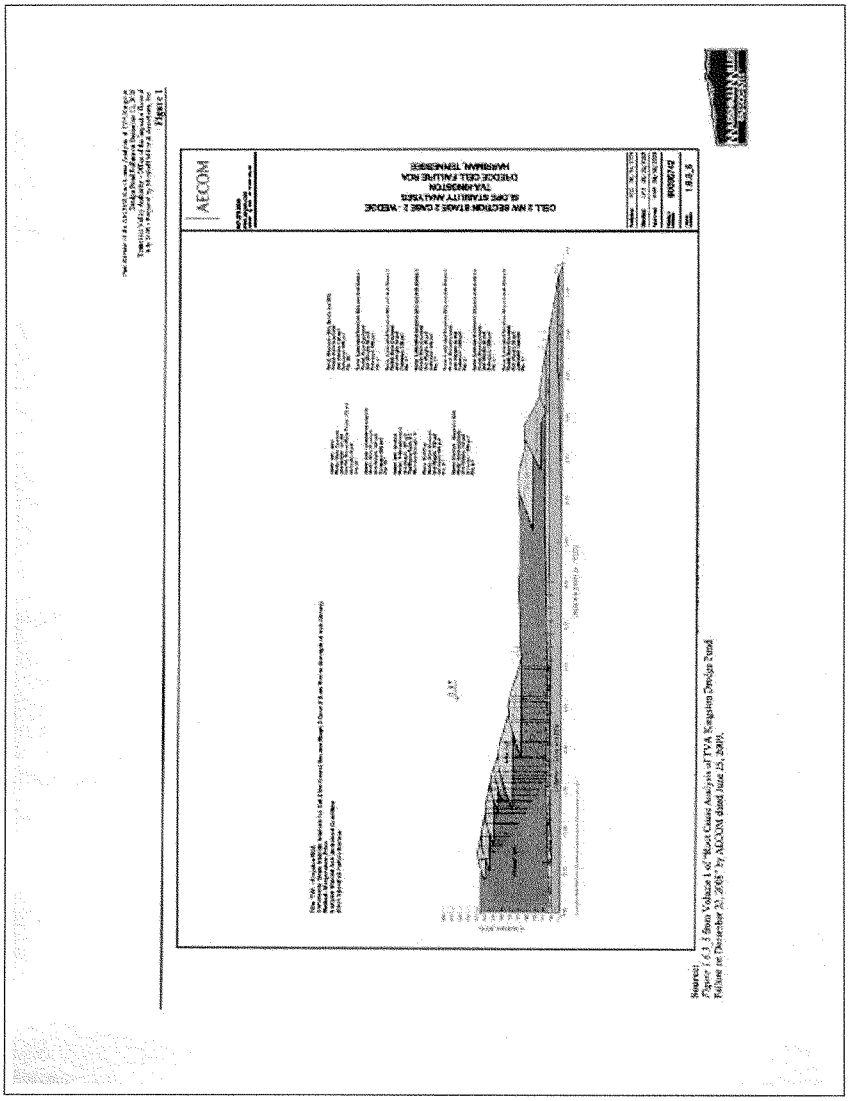
Signature of Qualified Person — July 9, 2009 (Date of Signing)

Christopher J. Lewis, P.E.[6]
Print Name of Qualified Person

[6] Christopher J. Lewis, P.E. is a Geotechnical Subconsultant of MM&A and is employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

FIGURES

MARSHALL MILLER & ASSOCIATES



Source:
Figure 1 of 3 from Volume 1 of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008," by AECOM dated June 15, 2009.

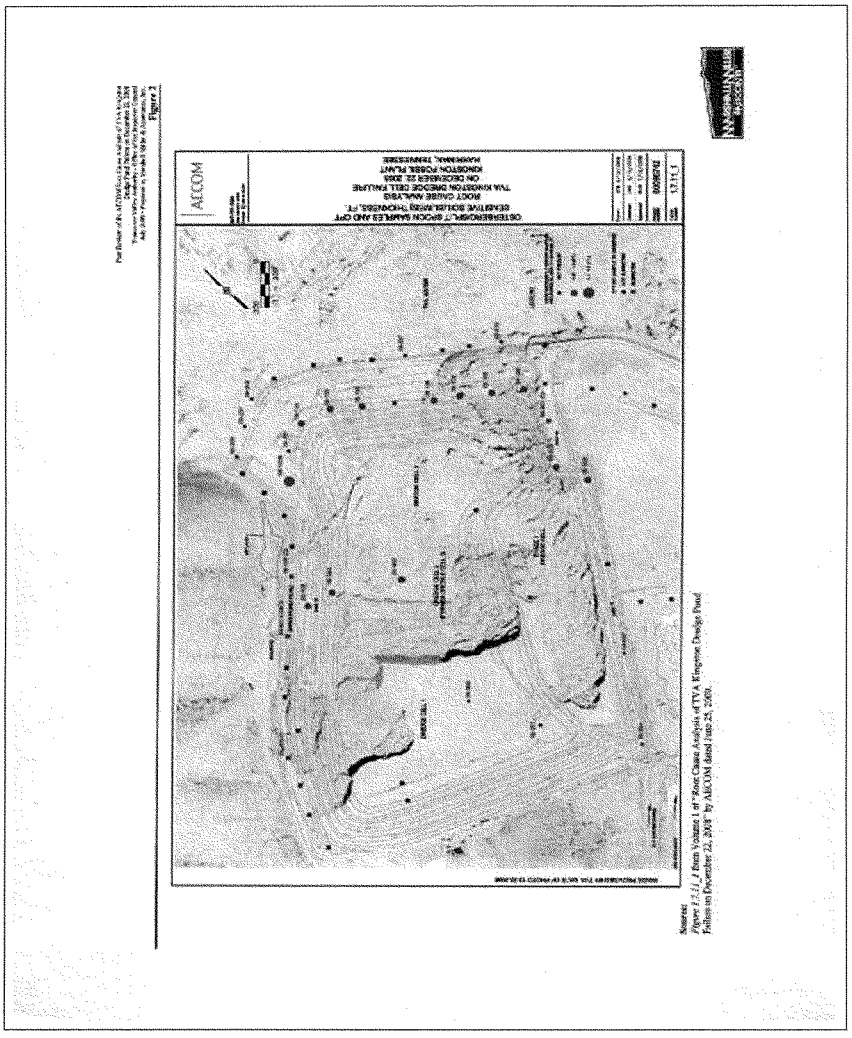
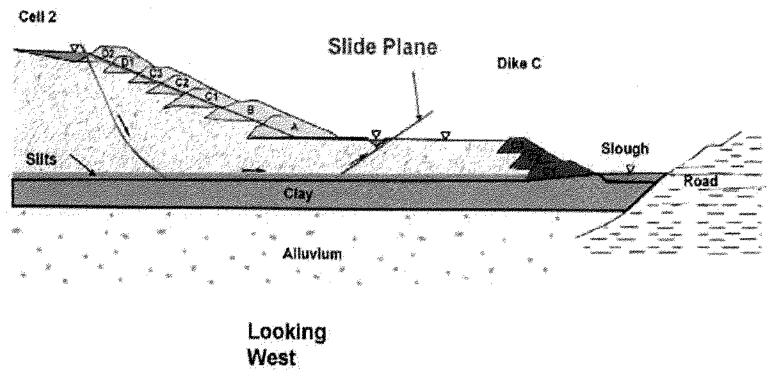


Figure 3

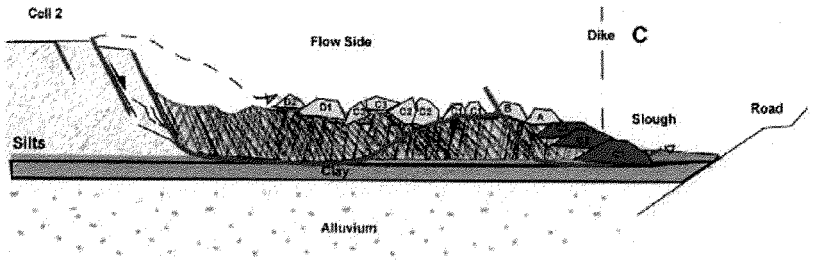
Stage 1 - Initiation of Failure at North Side of Dredge Cell 2



Source:
Figure 1.8_3 from Volume 1 of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" by AECOM dated June 25, 2009.

Figure 4

Stage 2 – Ash & Dikes A thru D2 Pile Up Against Dike C. This Surcharge and increased Ash Pressure Causes Dike C to Fail

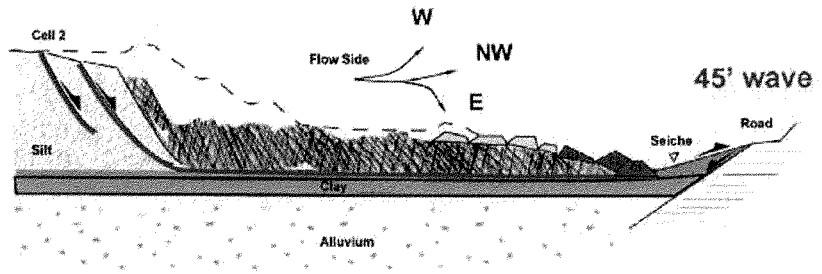


Looking West

Source:
Figure 1.8 5 from Volume 1 of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" by AECOM dated June 25, 2009.

Figure 5

Stage 3 – Progressive Failure Southward that Fails North Dikes A thru D2 Back to Cell 1 Divider Dike. 5.4 Million CY Fill Sloughs and Reservoir



Looking West

Source:
Figure 1.8_5 from Volume 1 of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" by AECOM dated June 25, 2009.

Report

Historical TVA Documentation Review Summary, Opinions and Recommendations Related to the TVA Kingston Dredge Pond Failure on December 22, 2008

Kingston Fossil Plant, Harriman, Tennessee
Project No. TVA101-01

Prepared for:

July 2009

TVA Office of the Inspector General
Knoxville, Tennessee

Prepared by:
Marshall Miller & Associates, Inc.
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Item 1: TITLE PAGE

Title of Report

Historical TVA Documentation Review Summary, Opinions and Recommendations
Related to the TVA Kingston Dredge Pond Failure on December 22, 2008

Project Location

The project site is located in Harriman, Roane County, Tennessee, and is situated on a peninsula formed by the confluence of the Emory River and the Clinch River.

Qualified Persons

William S. Almes, P.E.
Project Manager
Senior Engineer & Director of Geotechnical Services
Marshall Miller & Associates, Inc.

EDMUNDO JOSE LAPORTE
REGISTERED
No. 111570
STATE OF TENNESSEE
07/12/09

Edmundo Laporte, P.E.
Senior Project Engineer
Marshall Miller & Associates, Inc.

Christopher J. Lewis, P.E.
Principal Engineer
D'Appolonia, Engineering Division of Ground Technology, Inc.

Effective Date of Report

July 12, 2009

MARSHALL MILLER & ASSOCIATES

Item 2: TABLE OF CONTENTS

LIST OF EXHIBITS

Note: Exhibits 1 and 2 have been included within this report for reference only. All Exhibits were obtained from TVA OIG during its investigation of TVA archived documents.

Item 3: INTRODUCTION AND BACKGROUND

The **Tennessee Valley Authority (*TVA*) Office of the Inspector General (*OIG*)** engaged **Marshall Miller & Associates, Inc. (*MM&A*)** to conduct a peer review of the Root Cause Analysis (*RCA*) prepared by **AECOM Technologies Corporation (*AECOM*)** relating to the ash dredge cell failure which occurred at the TVA Kingston Fossil Plant (*Kingston*) near Harriman, Tennessee, on December 22, 2008. On June 25, 2009, AECOM publicized the results of its comprehensive six-month study entitled "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008." According to AECOM, the root cause of the failure was a complex set of conditions, including a long-evolving combination of the high water content of the wet ash, the increasing height of ash, the construction of the sloping dikes over the wet ash, and the existence of an unusual foundation layer consisting of sensitive slimes and silts.

MM&A prepared a report entitled "Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008", in which it concluded that the characteristics of the loose, wet ash indicate the wet ash as a probable root cause of equal or greater significance to the soft foundation soils. It also concluded that because the failure was not strictly associated with the "thin, weak slimes" layer and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

MM&A met with various representatives of the OIG, TVA, and AECOM, among others, during the course of its engagement, and was provided access to various documents including engineering design drawings, photographs, aerial maps, internal TVA memoranda and various reports produced by TVA's consultants, as well as other documents which were reviewed in the course of the engagement.

This report presents the following sections:

- A summary of the MM&A Project Team
- A description of the MM&A's scope of work

- A discussion of coal ash facility design practices and standards
- A summary of MM&A's review of TVA's historical documentation
- A timeline of events relative to the Kingston Dredge Pond / Disposal Facility
- Conclusions and observations

Item 4: MM&A PROJECT TEAM

MM&A, an employee-owned Engineering News-Record Magazine (*ENR*) Top 500 company, began offering geologic services to the mining industry in 1975 and has provided a full range of related services to the mining, utility, financial, governmental, and legal industries for 33 years. Today, MM&A employs nearly 200 engineers, geologists, scientists and other professionals working from regional offices in ten states.

It is noteworthy that members of MM&A's Project Team have been intimately involved with the development of the two engineering design manuals prepared by the **Mine Safety and Health Administration** (***MSHA***), which specifically address the procedures that should be followed for designing and operating coal refuse impoundments and embankments. The first manual was published in 1975, and an updated version is scheduled to be released in 2009. Although these manuals were written to address the design and operation of coal refuse disposal facilities, the key chapters, which include material characterization, hazard classification, planning, staging, foundation considerations, surface drainage and storm water control, instrumentation monitoring, geotechnical engineering and design, seismic hazard assessment, seismic stability and deformation, environmental considerations, and emergency action plans, are directly applicable to the disposal of fly ash and bottom ash materials

MM&A has also been involved with forensic studies of major waste impoundments that have experienced uncontrolled releases of fine slurry, as well as slope instability within portions of both coal ash embankments and impoundments, and coarse coal refuse dams.

The MM&A Project Team is comprised of the following professionals:

- Mr. Peter Lawson – Executive Vice President & Principal-in-Charge
- Mr. William S. Almes, P.E. – Director of Geotechnical Services & Project Manager for TVA OIG
- Mr. Edmundo Laporte, P.E. – Senior Engineer
- Mr. William M. Lupi, P.E. – Project Engineer
- Mr. John E. Feddock, P.E. – Senior Vice President & Senior Peer Review Team Member

- Mr. Richard G. Almes, P.E. – Principal Geotechnical Engineer & Senior Peer Review Team Member
- Mr. Christopher J. Lewis P. E. – Principal Geotechnical Engineer & Senior Peer Review Team Member[1]

[1] Christopher J. Lewis, P.E. is a Geotechnical Subconsultant of MM&A and is employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

Item 5: SCOPE OF WORK

In addition to the peer review presented in MM&A's July 9, 2009 report entitled "Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008," MM&A was also engaged to discuss its understanding of the historical development of the disposal facility as it relates to the siting, design and construction of the containment dikes at Kingston up to the time of failure on December 22, 2008. This report is intended to summarize MM&A's opinions concerning appropriate design philosophy, design standards, and construction and operations procedures that are applicable to ash disposal facilities. MM&A's opinions are based on extensive experience with a variety of mine waste embankments and impoundments that have been operating throughout the United States for several decades. MM&A will also comment on salient aspects of the evolution of the facility.

Understanding and acting on these findings are important to the prevention of a similar occurrence at other TVA wet disposal facilities that have active ash embankments and impoundments or similar structures planned for future use.

Item 6: Discussion of Coal Ash Facility Design Practices and Standards

6.1. Design Philosophy

Technically, dikes/embankments containing hydraulically placed or sluiced materials with the potential to impound water should be treated as dams. Compared to a dam constructed across a valley or hollow, expansive dike/embankment systems for coal ash storage can present greater uncertainties relative to the native foundation, hydraulically placed or sluiced materials, and dike/embankment materials.

Usually, dikes for wet ash storage and disposal facilities, as in the case of Kingston and other TVA fossil plants, are designed and built as upstream-constructed, staged embankments. This technique consists of constructing the first stage of the dike, or starter embankment, using soil, bottom ash or a similar competent material, while fly ash is used for the subsequent stages. The upstream construction method is the most economical construction method because it minimizes the quantity of earthwork and demand for earthen fill, relying largely on the ash materials (bottom ash and fly ash) for containment construction, and spreading the costs over a longer period of time compared to the development of a large starter containment dike/embankment. One of the limitations of the upstream construction method is that the individual dike stages must be relatively broad and the overall side slope of the staged dike system must be relatively flat (3H:1V to 4H:1V) to provide a safe, stable construction of a vertical succession of dike stages over hydraulically placed or sluiced wet ash. Also, the adequate design of the seepage collection and control system is particularly important, since the phreatic surface (groundwater pressures) may tend to advance close to the external face of the containment dike given the unique geometry of an upstream-constructed, staged dike system.

Upstream embankment construction designs are dependent upon the cross-sectional geometry that can be practically attained based on the rates of ash generation, projected maximum embankment height, shear strength of the embankment and sluiced materials, and the adequacy and long-term efficacy of seepage control features within the embankment and its foundation. Typically, the embankment geometry for the final proposed configuration, with all stages defined, will have a maximum height that will provide the required slope stability factor

of safety for the estimated material shear strengths and conservatively designed seepage control system (internal drains and seepage cutoffs/barriers). In most cases, once the designed maximum height has been reached for the particular embankment geometry, material shear strengths, and internal drain configuration, the only way to further increase the embankment height is to install downstream buttresses unless special construction or ground improvement methods are implemented to enhance the stability of the existing containment system and permit vertical expansion. Therefore, it is advisable that the facility's layout for an upstream-staged coal ash embankment allow for future downstream buttress zones when planning locations for access roads, drainage structures, and other fixed site features should vertical expansion be contemplated in the future.

Because permitting, design, engineering and construction requirements vary from state to state, the time period in which each disposal facility was designed and constructed may differ. Significant differences in subsurface conditons and/or operational practices might exist at any given site and between sites, overall stability of each individual disposal unit should be evaluated individually to identify the most critical sections and designed to preclude failure of these "weak links."

An additional factor to be considered in the design of a coal ash embankment is the potential for a seismically-induced slope failure due to earthquake effects acting on the embankment and possible significant strength loss (liquefaction) within any sluiced ash zones behind or under the staged embankments. Also, embankment stages founded over sluiced ash materials have the potential to settle differentially if an earthquake were to occur due to contraction of the sluiced ash. Settlement of the sluiced ash may cause the formation of cracks in the embankment, which can result in the settlement of the crest or prompt sloughs, all of which could aggravate seepage, create an overtopping potential, and reduce the stability of the embankment.

Upstream embankment configurations are more complex from an investigation, testing, design and construction standpoint and require closer scrutiny.

Because of the high sensitivity of hydraulically placed or sluiced coal ash, which is prone to significant deformations if caused to behave under undrained conditions, the design should not be predicated on its drained behavior of impounded ash. Moreover, some coal ash may be thixotropic material, that is, it may appear as a solid but will liquefy when vibrated or agitated. Furthermore, studies performed on fly ash in ponds have documented the fact that wet coal ash does not consolidate.[2] Instead, it maintains its relatively high void ratio notwithstanding the fact that it may have been stored for decades and that a considerable load may have been placed on top of it. This was also observed and reported by AECOM during the RCA investigation and mentioned as one of the characteristics of the sluiced ash that may have contributed to the failure.

6.2. Design Standards

The stability analyses of coal ash embankments are typically performed for static and dynamic conditions. A minimum factor of safety of 1.5 under normal static/steady-state seepage conditions is widely considered as the minimum acceptable value in the design of dams, landfills, and containment dikes/embankments.

Additionally, where the consequences of containment failure are significant with respect to potential property damage, environmental impacts, and/or loss of life, seismic stability and deformation potential also warrant evaluation.

MSHA is nearing completion of the publication of an updated "*Engineering and Design Manual, Coal Refuse Disposal Facilities*" which provides relevant guidance for the evaluation and design of earthen, mine waste, and similar containment structures for seismic loading. Per the MSHA manual, a minimum acceptable factor of safety during a seismic event under normal seepage conditions, using pseudo-static slope stability analysis, would be 1.2. If this limit cannot be met, a more rigorous dynamic analysis and evaluation is required.

6.3. Construction Documentation and Inspection

Ash disposal facilities, like other waste disposal facilities, are under constant construction, alteration, and expansion. Therefore, such facilities should be subject to regular

[2] Ground/Water Technology, Inc., "Dewatering to Stabilize Fly Ash Disposal Ponds", May 1985.

intervals of inspection; field/laboratory testing, reviews of internal drain and seepage barrier materials (as applicable) and installation procedures; as-built documentation/surveying; and technical review (e.g., annual dam safety inspection and periodic assessment of compliance with the approved design plan by the professional engineer of record). The frequency of these oversight aspects should in part be related to the rate at which the facility changes (expands, rises, and/or enters a new stage or phase of construction) and the timing of critical construction tasks (e.g., internal drain construction and principal spillway/outfall pipe installation).

6.4. INSTRUMENTATION AND MONITORING

A well-designed instrumentation plan and monitoring program provides insight into a structure's performance that cannot be ascertained from visual inspections. Also, the scheduled installation of instruments provides an ideal opportunity to explore the prevailing as-built subsurface conditions and to retrieve and test material samples for comparison with the design-phase findings, parameters, and inferences/assumptions.

Seepage development through a hydraulic containment dike/embankment system and its foundation is typically monitored via a network of piezometers, and regular measurement and recording of internal drain, relief well, and seep discharges. The phreatic surface within the embankment should be monitored over time to determine if internal drains have become significantly less effective because of clogging or other factors. This can be accomplished by monitoring multiple piezometers at critical sections of the coal ash embankment slopes. Seepage from internal drains should be recorded on regular intervals, and rainfall logs should be maintained to record the precipitation associated with each rainfall event and to track the cumulative precipitation over time. If necessary, a data logging, tipping-bucket rain gauge might be considered to automate this monitoring activity. The seepage rates, rainfall data and pool level in the ash pond should be recorded for comparison.

Deformation monitoring with automated instruments and/or other resources such as settlement monuments, extensometers or inclinometers would also be advisable to track the dike/embankment response throughout initial construction and thereafter. The frequency of instrumentation monitoring should be based on the hazard classification of the containment structure, its past performance, the rate of change in the facility's configuration, the regularity of

visual inspections, and governing state and federal regulatory agency requirements. The accumulated monitoring data should be reviewed regularly by a qualified geologist or engineer—monthly, quarterly, or annually, depending on the required or warranted frequency of instrumentation monitoring. Every year, the reviewing geologist/engineer should verify that the current constructed conditions are in reasonable conformance with the design and, if questionable, re-evaluate the stability of the constructed embankment using the highest recorded phreatic levels.

Item 7: HISTORICAL TVA DOCUMENTATION REVIEW & TIMELINE OF EVENTS RELATIVE TO THE KINGSTON DREDGE POND / DISPOSAL FACILITY

In a 1924 topographic survey, the Emory River elevation was below 710 feet (per *Figure 1.2.2_1* of the AECOM RCA report). In December 1941, the Watts Bar dam gates were closed and the reservoir began filling. The Watts Bar Reservoir normal pool elevation had been maintained at 745 feet in the summer and was typically lowered to 735 feet during the winter and spring months.

The Kingston Fossil Plant construction began in 1951. The first unit at Kingston was brought online in February 1954. Ash was initially discharged to slack waters in the Watts Bar Reservoir. In 1958, the northern 275-acre ash pond containment dike construction was completed. The approximate elevations of the base and crest of the Dike C berm were at 736 feet and 748 feet, respectively. The portion of the earthen Dike C that was installed below water level was reported to have consisted of a firm shale fill. The perimeter Dike C was installed with approximately 6 Horizontal to 1 Vertical (6H:1V) exterior slopes. The drawings did not specify any drainage filter zones or underdrains to control the phreatic surface within the Dike C perimeter embankment.

The initial ash disposal cell boundary dike was filled in 1965 to an elevation of approximately 746 feet. A second earthen dike fill was placed up to a top elevation of 765 feet with a top width of approximately 20 feet and 2H:1V interior and exterior slopes. In 1980, Cell 1 was constructed under the supervision of Fossil Power's Technical Services Branch. In 1986, Cell 2 and Cell 3 were added to the dredge cell complex. The stability analysis was checked by Fossil Engineering for a maximum elevation of 785 feet.

On April 3, 1985, Memorandum No. 850408C0373 was authored by R.G. Domer and presented attachments detailing a slope stability analysis of Dike C. The memo (also provided as **Exhibit 1**) stated the following: *"The minimum 'as built' factor of safety against dike slide failure is 1.2± ... Since a factor of safety of 1.5 is desirable, we recommend continued daily*

inspections of this dike by plant personnel."[3] The attachments to the memo presented the slope stability analysis results for the case of the existing two stages of the earthen Dike C embankments and a third compacted bottom coal ash embankment stage that was shifted 20 feet upstream and built with 4H:1V downstream slopes and a 60-foot wide top. It is noteworthy that the top width had been modified to only have a 12-foot top width, per the as-built section presented in *Figure 1.2.5_4* of AECOM's RCA report.

TVA had reviewed its coal ash disposal facilities and, in December 1988, W.M. Bivens, Vice President of Power Engineering and Construction, determined the following: "*[W]e believe ash disposal facilities, even those that contain significant amounts of ash sluice water, are not appropriate for inclusion in the TVA Dam Safety Program. Our position is based on the following: (1) ...It is clear that the intent of the guidelines is to regulate those facilities, including tailings or waste disposal ponds, which block natural streamflow. An ash pond, essentially a basin on flat ground, does not meet that definition. (2)... The basis for this position was both that the facilities were not dams per se as well as TVA is not strictly subject to the Federal guidelines (we do conform to them as a matter of policy), and (4)...Because of concerns about groundwater contamination, TVA is moving away from wet ash disposal techniques to dry stacking.*"[4] This memorandum is provided as **Exhibit 2**.

In 1995, the dredge cell complex was permitted to expand from an elevation of 785 feet to an elevation of 844 feet as a dredge cell and up to 868 feet as a landfill. The design was analyzed for stability by Fossil Engineering, and a landfill permit was obtained based on the design.

In 2003 a shallow slope failure occurred along Swan Pond Road. Two consulting firms retained by TVA, **Geosyntec Consultants, Inc. (*Geosyntec*)** and **Parsons Corporation (*Parsons*)**, analyzed the dike for stability and produced a repair design. A third firm, **MACTEC Engineering and Consulting, Inc. (*MACTEC*)**, an engineering consulting firm based in Atlanta, Georgia, was hired by TVA to provide consulting engineering services in support of the

[3] R.G. Doner, Director of Engineering Project, to C.C. Schonhoff, Director of Fossil and Hydro Power, 3 April 1985. Archived TVA files, Tennessee.
[4] W.M. Bivens, Vice President of Power Engineering and Construction, to Morris G. Herndon, Manager of Dam Safety Program, 29 December 1988. Archived TVA files, Tennessee.

APPENDIX C
Page 16 of 36

Kingston dredge cell facility. MACTEC installed monitoring wells and performed laboratory testing. In 2006, a second shallow slope failure occurred along Swan Pond Road. Geosyntec investigated and recommended the reconstruction of the slope, modification of the interior dimensions of the exiting riprap toe buttress, and addition of groundwater spring collection boxes. Geosyntec prepared monitoring criteria for the failed slopes and turned over the responsibility of monitoring to TVA. In accordance with correspondence between TVA OIG and MM&A, a member of the emergency response team who responded to the 2003 leak at the Swan Pond Road dike stated that one of the immediate responses was to put weight on the leak. TVA engineers recommended using 200 feet of riprap (rock). A contracted engineer recommended 250 feet of riprap. Reportedly, after installing 50 feet of riprap, the now-retired manager of Coal Combustion Byproducts stopped further installation of the material having said that it looked fine and that he wanted to wait to see what happened.

The aforementioned emergency response team member expressed grave concern that only 50 feet of the rock had been applied, but the former Coal Combustion Byproducts manager was considered the overriding expert at the time. The fix turned out to be fine, but the emergency team member was concerned that only 50 feet had been used when the other engineers recommended 200 to 250 feet. The manager of Coal Combustion Byproducts stated that when he arrived at the site, the area was very saturated. He was concerned about adding the additional weight of the stone and the weight of the trucks dumping the stone, so he stopped the riprap installation at a point where the riprap width was approximately 50 feet.

MM&A performed a review of the following sections contained within the 2004 TVA document entitled: "*Operations Manual–Dredge Cell Lateral Expansion*" dated June 1, 2004 (Revised March 27, 2006):

- *Appendix G: Stability and Seismic Impact Analysis* (a 32-page calculation brief prepared by Parsons and dated May 26, 2004)
- *Sheet 5: Dredge Cell Existing Conditions & Drainage Layer* (TVA Drawing No. 10W425-30)
- *Dredge Cell Lateral Expansion Phase 2/3 – Typical Cross Section & Details* (TVA Drawing No. 10W425-65)

Parsons reported on the results of a slope stability and seepage analysis it performed at TVA's request related to a proposed ash pond expansion design in support of the evaluation of the proposed Phase 2 and 3 Lateral Dredge Cell expansions. In that report, Parsons noted the existence of an approximately 7- to 10-foot thick layer of loose ash immediately overlying the clayey soil beneath the ash pond. Parsons further noted that this layer of loose ash may undergo liquefaction under certain circumstances, including a seismic event. Parsons stated that the probability of this occurring was "extremely low." However, Parsons then stated that methods of predicting liquefaction have proven to be "insufficient," and therefore recommended that TVA take measures to improve drainage in the ash pond. The seepage analysis recommended the installation of three additional shallow underdrains to reduce the seepage forces and exit gradient near the toe of the dredge cell slopes. The slope stability analysis was performed for the static case, and the corresponding yield acceleration was determined for the static stability models that would cause the slope to fail. However, the Parsons evaluation did not consider that the hydraulically placed/sluiced ash is especially prone to abrupt strength loss down to the steady-state strength under seismic loading, as well as under other relatively sudden changes in loading or loading rate that activate undrained response. Given this behavior and sensitivity of the loose, wet ash, minimal undrained shear strength should have been assumed for the loose, wet ash zone(s) when evaluating the post-earthquake/seismic stability and other conceivable load cases under which undrained ash behavior might govern stability.

The Parsons calculations and TVA's design drawings were evaluated by Geosyntec during a peer review. The peer review concluded that the seismic yield acceleration was below recommended values from two guidance documents and that justification should be provided for values presented in the calculations.

With regard to the proposed drainage system and liquefaction, Geosyntec also found that "[t]he potential for liquefaction should be estimated. Depending on the results of this estimate, a liquefaction analysis may be required. If the site is expected to liquefy then ground improvement techniques need to be implemented."[5]

[5] GeoSyntec Consultants, "Engineering Peer Review of Coal Byproducts Disposal Plans, Kingston Fossil Plant, Kingston, Tennessee", prepared for Tennessee Valley Authority, November 2004.

The influence of the drains was not calculated, therefore it is unclear if the drains would be effective at mitigating liquefaction. Upon review of correspondence between TVA-OIG and TVA, it is MM&A's understanding that the improvements had not been completed by TVA since the base area of the expansion had not been completed to the point where the proposed drainage blanket could be installed. Evidently, the drainage blanket needed to be constructed before the column drains could be inserted.

In 2005 Parsons performed seepage and slope stability calculations for the western slope of the dredge cells. The analysis recommended that three additional underdrains be installed at bench elevations 795±, 781± and 775± feet above mean sea level within portions of the embankment that did not contain underdrains. The three proposed drains were to be installed at a depth of approximately 5 to 6 feet. MM&A is not certain why existing underdrains were not installed at elevation 768± feet as part of the Stage A dike construction (i.e., the first shifted stage at the north side of the Dredge Cells). The slope stability analysis showed a factor of safety of 1.37± using the modeled phreatic surface that included the three proposed underdrains.

In April 2005, TVA requested a minor modification to Permit IDL 73-0094 from **Tennessee Department of Environment and Conservation (*TDEC*)** to repair a blowout that occurred in November 2003. This modification included the installation of three trench drains at existing benches at elevations 795±, 781± and 775± feet. Additionally, well points were installed to reduce the hydrostatic pressure within the riprap-lined drain. A reconfigured riprap buttress was installed at the toe of the embankment. The buttress included a toe underdrain consisting of a geosynthetic drainage composite to collect seepage and direct it to new drainage structures.

During the October 20, 2008, annual inspection of the Kingston dredge cell dikes, "redwater" seepage was reported at one of the well points (KWP-8) that had a closed valve.[6] The report stated that "[d]rain lines with valves were installed on the old dewatering wells to allow personnel to relieve some of the water in these wells."[7] The well points were installed in

[6] Chris Butram, "Kingston Fossil Plant, Annual Ash Pond Dike Stability Inspection, 2009" (Executive Summary, 2009 Kingston Ash Pond Annual Dike Stability Inspection), 12 January 2009, Page 8.
[7] Ibid, Page 7.

the western slope during repairs conducted in 2006. It is not clear if the drain lines were gravity lines or required pumping to control the water in the well points. No specific recommendations were made in the report addressing the elevated phreatic surface observed at well point KWP-8 or the other well points. The comment in the report that states "[t]he valves of the other monitoring wells were open and were flowing clear water to the drainage ditch" [8] is not clear as to whether the water flowing from these wells is an elevated condition relative to the ground surface or if an elevated or artesian condition is present at these locations."

Shortly after 12:00 a.m. Eastern Standard Time (*EST*) on December 22, 2008, the northern and central portions of Dredge Cell 2 of the ash disposal site failed, and an estimated 5.4 million cubic yards of ash were released in a progressive sequence of flow slides over a period of one to two hours. The ash spill extended outside of the Dredge Cell 2, covering approximately 300 acres of the Swan Creek flood plain and surrounding acreage.

[8] Ibid, Page 7.

Item 8: CONCLUSIONS AND OBSERVATIONS

The following outlines MM&A's conclusions and observations based on its review of AECOM's June 25, 2009, RCA report, as well as its review of various documents regarding Dredge Cell 2, a meeting with AECOM personnel at their Vernon Hills, Illinois, office on June 2, 2009, and briefings provided by AECOM during presentation and conference call meetings.

8.1. AECOM RCA

In summary, MM&A found the following with regard to AECOM's root cause study and culminating RCA report dated June 25, 2009:

- AECOM's RCA concludes in *Section 1.8*: "The failure on December 22, 2008 depended on all four factors [root causes], without them working in combination, the failure of Dredge Cell 2 would have not likely occurred on this date." In MM&A's professional opinion, the suggestion that all four factors had to work in combination to cause the failure diminishes and disregards the risks that were posed by the upstream-constructed dike configuration and disposal procedures and the ever increasing height of Dredge Cell 2. Given what was known about the ash material and the geologic conditions within the Kingston ash disposal facility before December 22, 2008, there was an unquantified probability of failure. Consequently, the sensitivity of the upstream-constructed containment dike system to changes in loading, loading rate, seepage regime, sluiced ash behavior, and other circumstances must be appreciated to preclude another catastrophic failure as occurred on December 22, 2008.

- Moreover, the stated objectives of the AECOM RCA do not encompass the task of identifying necessary changes in design philosophy, design standards, construction documentation, inspection and instrumentation to prevent another Kingston-type failure.

- Consequently, the root cause study and culminating report by AECOM defines the problem but does not provide clear direction to TVA in the form of technical

guidance for evaluating, designing, and constructing reliable containments for "wet" ash disposal now or in the future.

- MM&A believes that the AECOM RCA focused disproportionately on the significance of the thin, discontinuous, soft foundation layer (sensitive silt and slimes) as one of the most probable factors/root causes. The significance of the "Fill Geometry" factor/root cause should be equally emphasized. In the Kingston case, the specific complexities and uncertainties associated with the ash dikes/embankments constructed over the hydraulically placed or sluiced ash deposits (i.e., upstream-constructed containment) is an important component of the "Fill Geometry" factor and, in MM&A's professional opinion, is of equal or greater significance relative to the "Soft Foundation Soils" factor.

- The characteristics of the loose, wet ash (hydraulically placed/sluiced ash), such as the rounded particle shape, weakly fused and loose particle structure, sensitivity, consistently high void ratios with increasing depth (lack of consolidation behavior), along with the contractive undrained behavior and very low undrained steady-state shear strength evidenced in the laboratory tests, suggest it (wet ash) as a probable root cause of equal or greater significance to the soft foundation soils (weak, sensitive silt and slimes foundation layer).

- Other factors evaluated by AECOM as probable root causes should be strongly considered by TVA and the power generation industry as a whole in evaluating the condition and structural integrity of wet ash disposal facilities. Each one of these factors is critical and should be closely evaluated for all of the existing TVA ash handling and disposal facilities. These concerns and findings could have a significant effect on the requirements and standards of care for facilities throughout the Fossil Plant industry.

- MM&A concludes that, because the Kingston failure was not strictly associated with the "thin, weak slimes" layer, and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and

impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

8.2. GENERAL

During its historical record review, meetings and observations, MM&A determined the following:

- As early as 1985, intrinsic problems related to the stability of Dike C were mentioned, specifically in R.G. Domer's memorandum (**Exhibit 1**), which indicate that the calculated factor of safety was less than the minimum acceptable value of 1.5 and close monitoring was recommended to detect any potential signs of failure in lieu of changing TVA policies and procedures that would require that the ash pond be designed to the higher "dam safety" standard. No specific action by TVA appears to have been taken as per the reviewed documents.

- The construction of successive upstream stages to elevation 820 (approximate crest elevation of Dredge Cell No. 2 at the time of failure) above the original containment dike system ("Perimeter Dike C" - approximate crest elevation of 748 feet) may have contributed to an additional decrease in the factor of safety of the containment dike system. In essence, at the time of failure on December 22, 2008, this increase in constructed height equated to an approximate 70-foot increase in the height of the ash pond above the crest elevation of the original Perimeter Dike C.

- In MM&A's opinion, if TVA had included its ash ponds in the Dam Safety Program as discussed in December, 1988 when TVA decided against this policy, protocol would have been established for performing customary geotechnical exploration, in-situ and laboratory testing, dike seepage and stability analyses, and adherance to the higher "dam" design standards, and the probability of identifying some or all of the conditions that led to the KIF failure would have increased significantly.

- The design of the Kingston coal ash dredge cells should have included a thorough engineering evaluation of all potential failure modes.

- It is considered sound engineering practice to design such facilities with features that provide a reasonable degree of redundancy or "second line of defense" in the event that one or more of the systems become inoperable. To some extent, establishing higher factors of safety provide this protection. However, other considerations are appropriate such as specifying a sufficient number of internal drains in the event one or more become clogged or compromised in some fashion. The same applies to specifying the degree of compaction of the dike materials since weather conditions, the level of experience of the equipment operators and other variables can affect the final condition and ultimate behavior of the structure. In MM&A's opinion, it is important that this design philosophy be applied to all of TVA's ash disposal facilities.

- The recommendations made by Geosyntec following its peer review of the 2004 TVA document entitled "*Operations Manual–Dredge Cell Lateral Expansion*" were appropriate, and the failure of TVA to respond to such warnings and affect necessary revisions to the design shows that conservative engineering design principles were not being followed within TVA. Furthermore, had corrective measures been completed in a timely manner, it is possible that TVA could have potentially prevented the occurrence of the failure.

- With regard to the TVA reaction to the 2003 ash slope failure along Swan Pond Road, buttress construction was a reasonable immediate response. As an emergency response, buttressing areas of observed sloughing and/or seepage outbreak is a common and accepted reaction to arrest such immediate problem(s), pending prompt review and formulation of a more permanent remedial plan by a qualified geotechnical/dam engineer. If 50 feet of riprap addressed the immediate problem(s) and stopped or precluded the progression of the failure, then the decision of the manager of Coal Combustion Byproducts was reasonable under the emergency situation. However, use of riprap material alone without proper

filter materials between the existing ash dikes and riprap buttress, whether 50 feet or 250 feet wide, was not a technically acceptable longer term solution. Rather than adopting a "wait and see" approach with the 50-foot wide buttress, the problems and potential longer term solutions warranted prompt evaluation by a qualified geotechnical/dam engineer. If the ash ponds had been included in the Dam Safety Program, this closer evaluation and a more sound "engineered" solution probably would have occurred.

- It is evident from findings and recommendations in the Geosyntec report that, in addition to consideration for liquefaction, modifications to the expansion design should have been made to require compliance with a more stringent design configuration. Upon completion of the proposed Phase 2/3 expansion, which had not occurred at the time of the failure, more height and weight would have been added to what is now the failed ash pond. TVA's concurrence with the recommendations would have resulted in additional extensive analyses and modeling.

- It is not prudent to presume that, if the slimes layer observed in the failed section at Kingston does not exist at other plant sites, there is adequate stability of these structures. On the contrary, the information developed from the extensive studies conducted by both **Stantec Inc.** (***Stantec***) and AECOM indicates that there is a reasonable risk of other dike failures if changes are not made in the design construction, oversight, and operation of the wet ash disposal sites throughout TVA.

Item 9: CLOSING

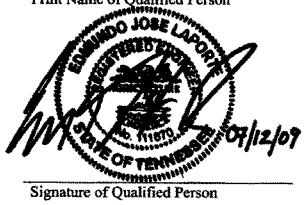
In preparing this report, the professional services of MM&A have been utilized, findings obtained, and conclusions made in accordance with generally accepted engineering principles and practices. MM&A reserves the right to amend and supplement this report based on new or additional information that might be obtained or become known. If OIG, TVA, TVA's consultants, or others discover additional information pertinent to the Kingston ash pond failure or related studies, MM&A requests the opportunity to review the information for significance relative to MM&A's findings and conclusions as presented herein.

Item 10: DATE AND SIGNATURE PAGE

The effective date of this Summary Report is July 12, 2009.

Signature of Qualified Person — July 12, 2009 (Date of Signing)

William S. Almes, P.E.
Print Name of Qualified Person



Signature of Qualified Person — July 12, 2009 (Date of Signing)

Edmundo Laporte, P.E.
Print Name of Qualified Person

Signature of Qualified Person — July 12, 2009 (Date of Signing)

Christopher J. Lewis, P.E.[9]
Print Name of Qualified Person

[9] Christopher J. Lewis, P.E. is a Geotechnical Subconsultant of MM&A and is employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

Item 11: LIST OF REFERENCES

The following references were provided to MM&A by TVA and were reviewed and used in preparation of this report:

1. Apple, M., Correspondence to Janet K Watts, TVA "Reuse of Coal Ash at TVA Facilities", TDEC, October 29, 2003.
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3. Bourquard, R.A., Kendrick, A.D., "Supplementary Soil Borings and Soil Permeability Evaluation, Proposed Demolition Waste Landfill Site", Ground Engineering and Testing Service, Inc., September 15, 1989.
4. Buchanan, G.L., "Kingston Steam Plant, Ash Disposal Dikes Raising Soils Investigation Report", TVA - Civil Engineering and Design Branch, November 3, 1975.
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12. Moses, D., Correspondence to Tennessee Press Service, Inc., "TVA - Kingston Fossil Plant, IDL 73-0094 - Final Permit Decision", Tennessee Department of Environment and Conservation, September 28, 2000.

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15. Reed, E.A., Correspondence to Tennessee Valley Authority Fossil Power Group, "Public Notice of Receipt of Part I Application – Proposed Lateral Expansion TVA Kingston Fossil Plant Class II Landfill – IDL 73-0094", TVA, January 20, 2004.

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17. Tockstein, C.D., Haston, M.B., Justice, C.T., "Report of Geotechnical Exploration, Ash Disposal Area, TVA Kingston Fossil Plant, Kingston, Tennessee", MACTEC, May 4, 2004.

18. Tockstein, C.D., Benkhayal, H.A., "Report of Geotechnical Exploration Monitoring Well Installation - Ash Disposal Area, TVA Kingston Fossil Plant, Kingston, Tennessee", MACTEC, February 23, 2005.

19. Tockstein, C.D., Justice, C.T., "Report of Monitoring Well Installation, Dredge Cell Dike Restoration, TVA Kingston Fossil Plant, Kingston, Tennessee", MACTEC, September 16, 2005.

20. Parsons E&C, "Presentation - Proposed Dredge Cell Repair Supporting Information", April 2005.

21. Parsons E&C, "Presentation –Final Trench and Trench Buttress Configuration for Dredge Cell III Swan Pond Road", undated.

22. Watts, J.K., Correspondence to, Tennessee Department of Environment and Conservation, Division of Solid Waste Management "TVA Request Approval for New Dredge Cell - Kingston Fossil Plant (KIF)", TVA January 6, 2004.

23. Walton, W. H., Butler, W., "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008", AECOM, Vernon Hills, IL, June 25, 2009.

EXHIBITS

TED STATES GOVERNMENT

lemorandum

8504080373 (5)

TENNESSEE VALLEY AUTHORITY
B65 '85 040 001

: C. C. Schonhoff, Director of Fossil and Hydro Power, 716 EB-C

M : R. G. Domer, Director of Engineering Projects, W12A5 C-K

E : APR 03 1985

JECT: KINGSTON STEAM PLANT - DIKE C SOILS INVESTIGATION AND ENGINEERING STUDY RESULTS

We have completed the soils investigation and engineering analysis for dike C. As you are aware, the dike was not built according to design drawings. A layer of ash extends to within a few feet of the exterior of the dike slope (see attachment A).

The minimum "as built" factor of safety against a dike slide failure is 1.2± (see attachment B). Since a factor of safety of 1.5 is desirable, we recommend continued daily inspections of this dike by plant personnel.

Construction of an engineered dredge pond dike adjacent to dike C will not increase the probability of a slide failure of the exterior dike; however, the dredge pond would increase the risk of seepage through dike C. The new dredge dike must be constructed in accordance with attachment C.

At one zone in the stilling pool compartment (see attachment D), the ash layer transports ash pond water to the exterior surface of the dike. OE will recommend a repair scheme and submit an order of magnitude cost estimate to you by April 26, 1985.

Original Signed By
R. G. Domer

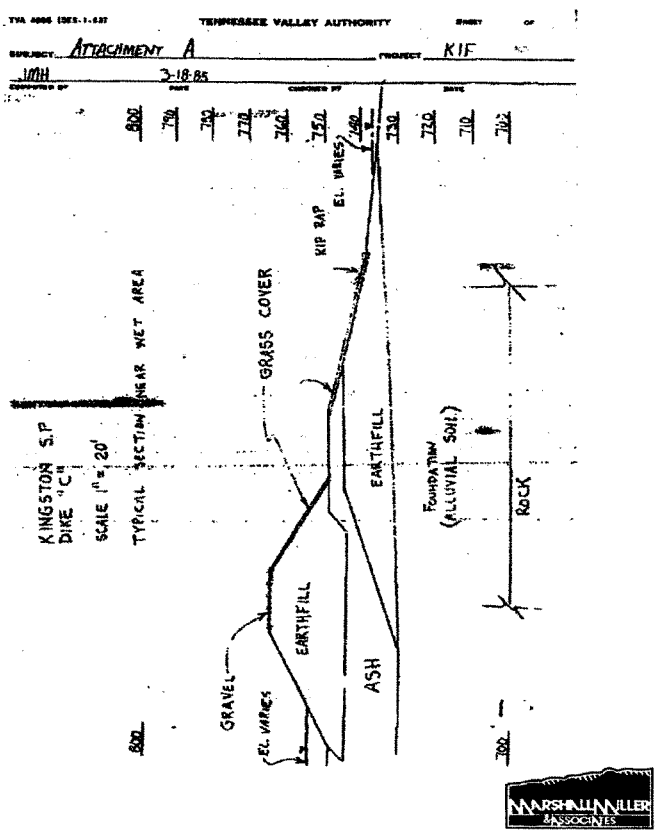
OPT:MRH:EFS
Attachment
cc (Attachment):
RIMS, SL26 C-K
R. O. Barnett, W9D22₄ C-K
C. Bonine, 12-108 SB-K
C. A. Chandley, W7C126 C-K
O. P. Thornton, W3D224 C-K
F. Van Meter, 10-103 SB-K (3)

Principally Prepared By: M. H. Miller, Extension 3806

S65085.01

BS/PDS
BDS:

MARSHALL MILLER & ASSOCIATES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ATTACHMENT A
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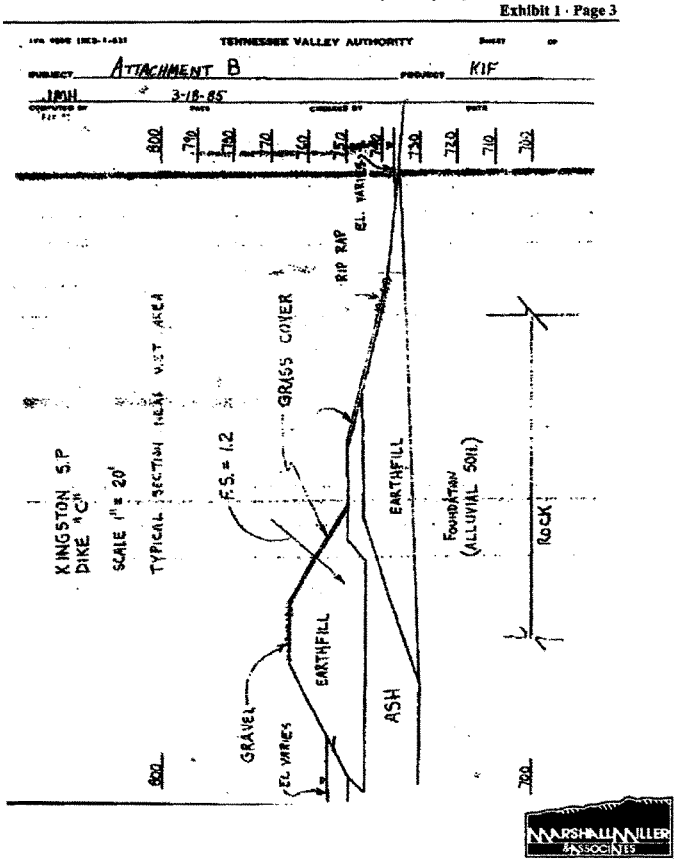
3-18-85
KINGSTON S.P.
DIKE "C"
SCALE 1" = 20'
TYPICAL SECTION NEAR WET AREA
GRASS COVER
RIP RAP
EL. VARIES
EARTHFILL
FOUNDATION (ALLUVIAL SOIL)
ROCK
GRAVEL
EARTHFILL
ASH
EL. VARIES
MARSHALL MILLER & ASSOCIATES


TENNESSEE VALLEY AUTHORITY
ATTACHMENT B
KIF
3-18-65
KINGSTON S.P.
DIKE "C"
SCALE 1" = 20'
TYPICAL SECTION NEAR WEST AREA
F.S. = 1.2
GRASS COVER
RIP RAP
EL. VARIES
EARTHFILL
ASH
FOUNDATION
(ALLUVIAL SOIL)
ROCK
GRAVEL
EL. VARIES
EARTHFILL
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760
750
740
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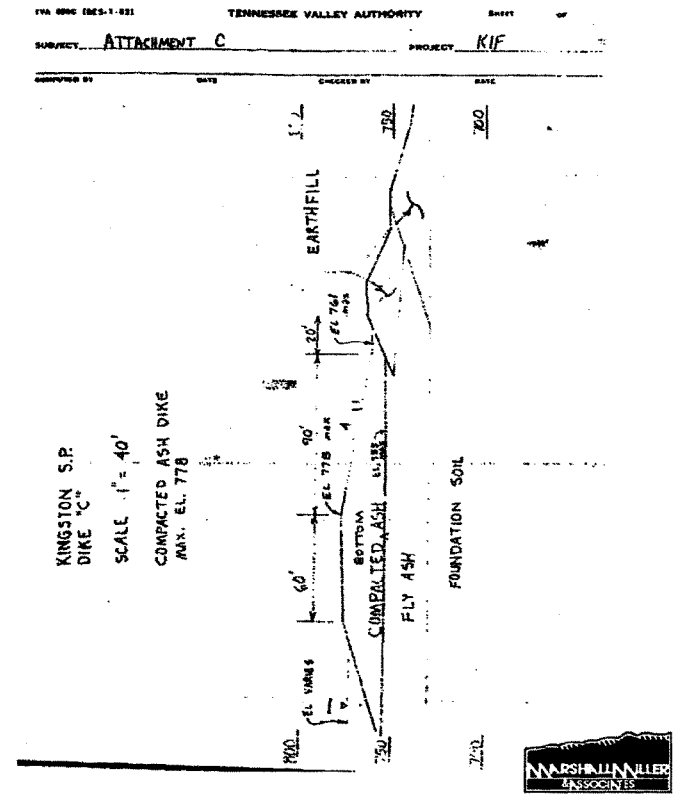
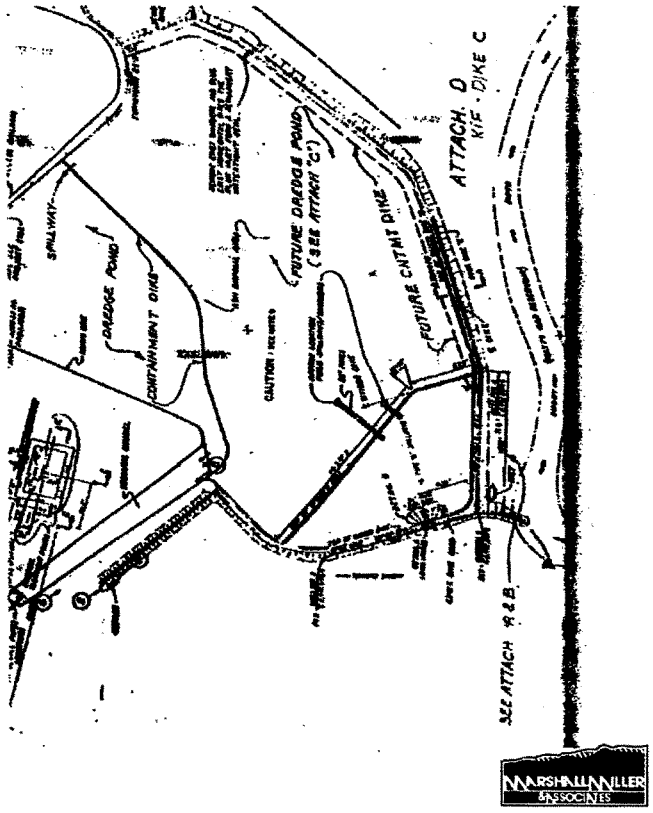
720
710
700
MARSHALL MILLER
& ASSOCIATES


TENNESSEE VALLEY AUTHORITY
ATTACHMENT C
KIF
KINGSTON S.P.
DIKE "C"
SCALE 1" = 40'
COMPACTED ASH DIKE
MAX. EL. 778
EARTHFILL
BOTTOM
COMPACTED ASH
FLY ASH
FOUNDATION SOIL
MARSHALL MILLER & ASSOCIATES


ATTACH. D
KIF - DIKE C
FUTURE DREDGE POND
(SEE ATTACH "C")
FUTURE CNTMT DIKE
SPILLWAY
DREDGE POND
CONTAINMENT DIKE
CAUTION
SEE ATTACH "A & B"
MARSHALL MILLER
& ASSOCIATES

DRAFT

TO: MORRIS G. HERNDON, MANAGER, DAM SAFETY PROGRAM, 350 NB-K

FM: W. H. RIVERS, VICE PRESIDENT OF POWER ENGINEERING AND CONSTRUCTION, LP 3S 60K-C

DT: DECEMBER 29, 1988

RE: RELATIONSHIP OF ASH DISPOSAL AREAS TO DAM SAFETY

This is in response to your November 10 memorandum to me in which you sought our opinion as to which ash ponds may meet the Federal guidelines definition of "dam", and further, their inclusion as facilities under the Dam Safety Program.

TVA has consistently taken the position that such facilities do not constitute "dams" as defined by FEMA in the Federal Guidelines for Dam Safety and believe that no change to that position is warranted. In addition, we believe ash disposal facilities, even those that contain significant amounts of ash sluice water, are not appropriate for inclusion in the TVA Dam Safety Program. Our position is based on the following:

1. The FEMA definition of "dam", which your memo quotes in part, also includes the phrase "which impounds or diverts water" and refers to "the natural bed of the stream or watercourse" as a benchmark for determining applicability. It is clear that the intent of the guidelines is to regulate those facilities, including tailings or waste disposal ponds, which block natural streamflow. An ash pond, essentially a basin on flat ground, does not meet that definition.

2. In its environmental permitting experience, TVA has occasionally submitted dam safety information to State (notably Kentucky) dam safety officials. We were careful to clarify that the data was being provided for information only in order to facilitate the processing of the permit application. The basis for this position was both that the facilities were not dams per se as well as TVA is not strictly subject to the Federal guidelines (we do conform to them as a matter of policy).

3. The electric utility industry does not generally register ~~any of its~~ ash disposal facilities with State emergency management agencies.

4. Because of concerns about groundwater contamination, TVA is moving away from wet ash disposal techniques to dry stacking. While not prohibited by the applicable environmental

regulations, it is quite unlikely TVA will construct any new ash ponds.

5. In our view, these facilities are appropriately managed and maintained as pollution control facilities. They already receive routine structural inspections, effluent quality checks, and other measurements (active volume certifications, etc.). ~~We can identify no particular advantage with reassigning their management responsibility to the Dam Safety Program.~~

Accordingly, ~~we recommend that~~ responsibility for ash disposal facilities should remain outside of the auspices of the Dam Safety Program.

The technical information you requested in your November 10 memo is attached for your information.

Please contact me or Jim Coulson with any additional questions on this matter.

JLG:WMP:smp
Attachment
cc: R. L. Copeland
J. L. Golden
W. G. Huffner

03711

1.1.2 Objectives and Scope of Work

AECOM was retained to perform a Root Cause Analysis (RCA) of the December 22, 2008 dredge cell failure to determine the most probable cause(s) and location of failure at the site. AECOM conducted interviews, reviewed project files, performed site reconnaissance, drilled test borings, advanced piezocone probes, collected undisturbed samples, observed test pits, logged test trenches, performed laboratory testing and conducted seepage and stability analyses to define the probable failure mode leading up the sudden failure. A summary of the RCA methodology employed by AECOM follows:

- Define the problem
- Gather physical data/evidence
- Identify the technical issues impacting failure
- Perform testing and analyses
- Identify the root causes (most probable failure scenario)
- Report the findings
- Peer review remedial designs by others at Kingston and to check if the designs are consistent with the post-failure geotechnical conditions encountered in AECOM investigations

AECOM was not assigned to opine or offer services in the following areas:

- Review the standard of practice used by TVA or their consultants for the design and construction of the ash ponds and dredge cells
- Review the fate and transport of potential ash and possible contaminates from the cells into environment
- Design of remedial construction measures to clean-up and restore the Kingston site
- Review of designs and operations at other TVA wet dredge cell disposal sites

It was not AECOM's charge to implement the restoration program nor was it to institute performance monitoring to ensure effectiveness of the restoration/cleanup program. This work was and will be performed by TVA or by consultants and contractors retained by TVA.

July 20, 2009

Richard W. Moore, ET 4C-K

REQUEST FOR COMMENTS - DRAFT INSPECTION 2008-12283-02 - REVIEW OF KINGSTON FOSSIL PLANT ASH SPILL ROOT CAUSE STUDY AND OBSERVATIONS ABOUT ASH MANAGEMENT

I am attaching a summary of management's response to the subject report, which was transmitted to me on the evening of July 13. The report and attachments consist of over 100 pages of detailed materials, so it is obviously difficult to respond in the type of detail that may be warranted.

As a preliminary matter I want to emphasize that since the time of the Kingston ash pond failure, TVA has taken responsibility for the cleanup and recovery of the site, has worked diligently with the community, and has made substantial changes within TVA. We will of course continue those efforts, as well as the thorough and comprehensive analysis of TVA's other impoundments that is currently underway, and the other efforts that we are undertaking to prevent such an event from ever happening again at TVA.

I understand the concern that OIG is now addressing about the scope of the root cause analysis, and I want to emphasize that our work here is far from finished. Our first step was to fully and completely understand, from an engineering and forensic perspective how the failure actually occurred physically, and then to apply that knowledge in our assessment of TVA's other impoundments. We feel that the AECOM report gives a very sound factual basis that we can build on going forward.

On a parallel track, the Board's counsel, McKenna Long & Aldridge, has been performing a review to determine, among other things, what remediation is necessary to processes, systems, and accountabilities to prevent an event like Kingston from happening again.

Other corrective actions, both physical and cultural, will occur. We have more work to do, and we welcome all comments about the physical and organizational deficiencies that may have contributed to this event. There was no intent to do anything except a completely independent root cause of the Kingston ash pond failure, and to move toward remedies for all causes found.

Tom Kilgore
President and Chief Executive Officer
WT 7B-K

Attachment

Attachment
Response to Specific Recommendations

Our responses to the report's six specific recommendations are as follows:

Recommendation:

Commission a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout TVA and measuring positive changes in the culture that effects ash management and other TVA programs.

Response:

I am committed to driving positive cultural change. Some changes have already been implemented by TVA by establishing the new Coal Combustion Products (CCP) organization that is separate from the fossil plants and which brings operations, maintenance, engineering, and projects under a single executive. Organizational program and process changes linked to culture change have been initiated in Fossil Generation earlier this year and are ongoing. More broadly, TVA is also implementing a cultural focusing initiative across the agency, incorporating lessons learned from Kingston.

Recommendation:

Assess the culture of the fossil fuels group to determine what changes need to be made, if any, to insure the support for sound policies and procedures related to ash management.

Response:

Responsibility for ash management now resides in the CCP organization; significant changes already have resulted in that area, and these efforts will continue.

Recommendation:

Assess the management practices of TVA for ash management to determine whether those practices contributed to the failure of the dike at Kingston.

Response:

Now that TVA has a detailed, technical explanation of what and how the Kingston dike failure occurred, we are better suited to make more specific inquiries as to how the failure could have been prevented in fact and, more importantly, what steps we can take to ensure that it never happens again and to safely close the failed cell.

Recommendation:

Complete the assessments of TVA ash storage facilities and determine which ones are at risk of failure. The determination should be, as suggested by Marshall Miller, based on whether any of the four conditions contributing to the failure at Kingston exist sufficiently to pose a significant risk of failure. The determination should not be limited to just looking for the existence of the combination of all four contributing conditions found at Kingston.

Response:

The comprehensive program for assessment of all of TVA's combustion by-product impoundments has been underway since January. The Phase One report of that assessment was publicly released on July 16, 2009. That assessment is not, and never has been, limited to determining whether the four conditions found to have combined to cause the Kingston failure exist at any other facility, either alone or in combination. While the causes of the Kingston failure, now that they are known, certainly are considered, each site is being fully evaluated based on any design or risk factor applicable to it, whether such a factor was identified for Kingston or not.

Recommendation:

Develop policies and procedures for the storing, handling, and maintaining of ash and ash disposal facilities.

Response:

More detailed and rigorous policies and procedures for storing, handling, and maintaining ash and ash disposal facilities are being developed and implemented in the CCP organization, and a comprehensive program for future CCP remediation and conversion is being developed and implemented.

Recommendation:

Continue the efforts to drive the Enterprise Risk Management Program further down into the organization to increase the future likelihood that known risks will be identified and addressed.

Response:

TVA is implementing improvements to its ERM to better achieve the goals of the program.

Ms. JOHNSON. The central thrust of this hearing, however, involves the future. Can the Tennessee Valley Authority assure Congress and the people of the Tennessee Valley region that its other coal ash disposal facilities are sound? In other words, can they ensure that they will not collapse, that they will not leech toxins into the groundwater, and that TVA facilities will not discharge carcinogenic and harmful substances into our Nation's waters?

This second issue, informed by the TVA OIG and McKenna reports, leads us to a subsequent line of questions that the Subcommittee must get answers to, either in this meeting or in other hearings in the months ahead. Can TVA provide the public with credible risk assessments regarding the safety of its facilities, including its coal ash impoundments?

Will the ongoing management and organizational changes occurring within TVA produce results that address all of the McKenna and TVA OIG report findings? Does TVA intend to become a proactive environmental steward? If so, how? Does the Congress need to take action to ensure that TVA facilities cease to pose threats to public safety, human health, and the environment?

Today's hearing is troubling. These recently released reports indicate a management culture at TVA that is slow and sometimes resistant to change. Testimony from our witnesses today will help guide this Subcommittee to whether change must be instilled upon this Federal entity. It will only be through both acknowledgment of the issues that resulted in the Kingston collapse and an active effort to address these issues that TVA will be able to move forward.

Thank you. I now recognize our Ranking Member, Mr. Boozman.

Mr. BOOZMAN. Thank you very much, Madam Chair. Today this Subcommittee continues its review of coal ash storage, specifically the December 22nd, 2008 incident at the Tennessee Valley Authority's power generating facility in Kingston, Tennessee.

While public and private utilities have safely operated approximately 600 coal ash sites for decades with only a few documented failures, it is important to recognize that this spill directly impacted more than 40 property owners. Homes were rendered uninhabitable. Water mains and gas lines ruptured. Nearby neighborhoods had to be evacuated. It is my sincere hope that what occurred at the Kingston coal ash disposal site was an isolated incident.

The witnesses today will discuss the causes of the accident and report on some of their observations about the Kingston site. In addition, these witnesses will address the agency culture within the Tennessee Valley Authority and how this may have contributed to the accident at Kingston.

As George Romney once said, "Nothing is as vulnerable as entrenched success." Traditionally, the Tennessee Valley Authority has been a good steward of the environment. Most of its employees, including some of the witnesses today, reside within the Tennessee Valley and are directly impacted by the actions taken by the agency.

Additional laws or Federal regulations would probably not have prevented this terrible accident. New laws and regulations will not replace homes, family treasures, heirlooms, or other personal prop-

erty lost as a result of the Kingston spill. However, this is little comfort for those property owners impacted by the Kingston spill who have sacrificed a great deal and who in some cases have forfeited their homes and other irreplaceable memories to this accident.

Moving forward, it is important for the Tennessee Valley Authority, its Board of Directors, and its officers to review the agency's existing ash management practices, recognize any shortcomings, and subsequently make changes to ensure more appropriate risk management at its facilities. Due to its proximity to the Emory and Clinch Rivers, the Kingston site carried an elevated risk. However, the Tennessee Valley Authority needs to take aggressive steps at its other coal ash storage facilities to identify and reduce risk to the public and to the environment.

Compliance at all levels within the Tennessee Valley Authority will help restore the level of trust that is expected of one of the Nation's largest power providers. The benefits that the Tennessee Valley Authority bring to the Nation are too important to be threatened by poor structures and poor management practices.

I am encouraged by some of the recent statements by TVA management that indicate they get the message and intend to emerge from this accident a better agency. I hope that we can help them.

I thank you, Madam Chair, for holding this hearing. I look forward to the testimony of the witnesses. With that, I yield back.

Ms. JOHNSON. Thank you very much.

The Chair now recognizes Mr. Duncan for an opening statement.

Mr. DUNCAN. Thank you very much, Madam Chairwoman. I don't have a formal written statement but I will say this: This spill was not in my district but it is 40 miles, roughly, from Knoxville.

I sent a member of my staff very soon after this happened out there. A few days later I went out there and took a helicopter tour and got a briefing. I have mentioned before that I met with all kinds of people working for TVA and other Federal, State, and local environmental agencies. I also met with contractors. I have since met with others in regard to this spill, participated in a meeting at Senator Alexander's office with interested parties including some of the victims, and have also participated in two previous hearings of this Subcommittee. I think I have made my views pretty well known on this.

TVA has been filled for years almost entirely with environmentalists in the best sense of that word. I understand that this retention pond and this system of storage was built in 1985, long before any of the current leadership of TVA was in there. All through those years the environmentalists at TVA, the EPA, and other agencies thought that this was just fine. Nobody really said anything about it.

Now, this is a terrible thing that has happened to TVA and it is horrible for the people who have been severely damaged. But I have always said that I think everything within reason that could be done should be done. I think it has been done. The progress that has been made has been amazing.

In our last hearing it was estimated that TVA's costs on this would be about $1 billion. That may be a lowball estimate, not counting the regulatory fines and lawsuits. Now, my feeling is that

if you disregard people who have a vested monetary interest in this because they are connected to some environmental group that wants to get contributions and make money out of this, and if you put aside the contractors—and all these are good people—but if you put aside the views of the contractors who have a vested or monetary interest in this, if you put aside all those people who are not tied into one of those groups, I think 95 or 98 percent of the people who take a look at this would say that TVA has done and is doing everything humanly possible to get this area cleaned up.

The progress has been tremendous. I think in the end this area is going to be cleaner than a lot of other areas around the Nation. You can never satisfy the extremists or the kooks in any situation. There will be some people that we will never satisfy no matter if we spent the entire Federal budget on this problem. But we have to be reasonable. We have to have a little balance and common sense in this situation. I think that TVA should be commended for all that they have done, are doing, and will do in regard to this situation.

Thank you very much.

Ms. JOHNSON. Thank you very much.

Are there any other statements?

Mr. CAO. Yes, Madam Chairwoman. First of all, I would like to thank you, Madam Chairwoman, for holding this important hearing. I will keep my remarks brief but I would like to take this opportunity to make some parallels between my community and the community experience at Kingston in regards to the spill.

In December of 2008, a retention wall at Kingston Fossil Plant failed, releasing 5.4 million cubic yards of ash and 327 million gallons of water onto the land and into the nearby rivers. The result of this failure was the release of five million cubic yards of coal ash into the Emory River and 300 acres of land being filled with sludge, in some places up to six feet deep. This spill caused extensive disruption to the neighboring communities with evacuations and the loss of power and gas, not to mention the houses that were destroyed in the tidal wave of ash and water.

It is a miracle that no lives were lost at the time of the spill. However, we do recognize the one life that was lost during the cleanup earlier this month.

As the Representative of the second Congressional district, I have great empathy for the communities that were directly affected by this unexpected and unprecedented event. I am also well aware of the effect failures in protective structures can have on surrounding communities.

The damage to Orleans and Jefferson Parishes four years ago wasn't because Hurricane Katrina made a direct hit on New Orleans. Instead, it was because the strength of the storm surge caused catastrophic failures in levees and flood walls throughout the city, especially in New Orleans East and the Lakeview area on the border with Navarre. The damage from these breeches included flooding in 80 percent of the city, damage to 80 percent of the buildings, and damage to 40 percent of our housing stock. Because of these failures, the city remained under water for days and in some places weeks. But, like the Kingston spill, the environmental hazards were great. We all remember the images of the waters through

which my constituents had to wade to get food and water. These were commonly referred to as a toxic soup because they were filled with sewage, gasoline, and oil, to say nothing of bacteria and disease.

Like you, Madam Chairwoman, in the immediate aftermath of the catastrophic failures that occurred as a result of Hurricane Katrina, I sought accountability and assurances from the Federal Government, especially the Army Corps of Engineers, that repairs would be made to ensure such catastrophic failures never happen again.

Through my work on this Committee and Subcommittee, I am closely overseeing the work of the Army Corps to ensure they are rebuilding our infrastructure to its former strength and beyond. One of my priorities is ensuring the complete rebuilding of the 17th Street and London Avenue Canals. I have cosponsored legislation which states this. I continue to work with the Army Corps and my delegation to ensure this protection is achieved for my constituents. Just like the community affected by the Kingston spill, my district cannot afford another disaster.

Again, Madam Chair, thank you for holding this important hearing. I look forward to working with you as you continue your oversight of this important matter. Thank you very much.

Ms. JOHNSON. Thank you very much.

Testifying first is EPA's Assistant Administrator for Solid Waste and Emergency Response, Mr. Mathy Stanislaus. Accompanying Mr. Stanislaus is the Acting Regional Administrator for EPA's Region 4, Mr. Stan Meiburg. Mr. Meiburg will be available for questions. Our second witness is TVA's President and CEO, Mr. Tom Kilgore. Following him is Mr. William Walton, Vice President and Senior Engineer with AECOM.

Our fourth witness is the TVA Inspector General, Mr. Richard Moore. Our final witness this morning, Mr. William Almes, is a Senior Engineer and Director of Geotechnical Services with Marshall Miller & Associates.

Your full statements will be placed in the record. We ask that you try to limit your testimony to about five minutes as a courtesy to the other witnesses.

I now recognize Mr. Stanislaus.

TESTIMONY OF MATHY STANISLAUS, ASSISTANT ADMINISTRATOR, OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE, U.S. ENVIRONMENTAL PROTECTION AGENCY, ACCOMPANIED BY STAN MEIBURG, ACTING REGIONAL ADMINISTRATOR, REGION 4; TOM KILGORE, PRESIDENT AND CHIEF EXECUTIVE OFFICER, TENNESSEE VALLEY AUTHORITY; WILLIAM H. WALTON, VICE PRESIDENT AND SENIOR PRINCIPAL ENGINEER, AECOM; RICHARD MOORE, INSPECTOR GENERAL, TENNESSEE VALLEY AUTHORITY; AND WILLIAM S. ALMES, SENIOR ENGINEER AND DIRECTOR OF GEOTECHNICAL SERVICES, MARSHALL MILLER & ASSOCIATES, INCORPORATED

Mr. STANISLAUS. Madam Chairwoman and Members of the Subcommittee, thank you for the opportunity to provide testimony on the U.S. Environmental Protection Agency's role in the response

and cleanup of the release of coal ash from the Tennessee Valley Authority Kingston plant.

Appearing with me today is Mr. Stan Meiburg, Acting Regional Administrator for EPA Region 4. Mr. Meiburg will be able to answer any questions you may have regarding Region 4's efforts related to the Kingston spill response.

I will summarize my testimony but I ask that my entire statement be submitted for the hearing record.

As you know, Madam Chairwoman, TVA's Kingston facility suffered a catastrophic failure, releasing an estimated 5.4 million cubic yards of coal ash into the Emory and Clinch Rivers and surrounding areas. Shortly after learning of the release, EPA deployed an on-scene coordinator to the site. EPA joined TVA, the Tennessee Department of Environment and Conservation, and other State and local agencies in a coordinated response. EPA served as the lead Federal agency throughout the emergency phase of the response and provided oversight and technical advice to TVA.

On January 12th of 2009, the Tennessee Department of Environment and Conservation issued an order to TVA to develop a corrective action plan to address the spill and to conduct a root cause analysis to determine the cause of the dike failure. Over time, the lead Federal agency designation transitioned to TVA as cleanup efforts moved into the recovery phase.

Subsequently, on May 11, 2009, EPA entered into an administrative order and agreement on consent, AOC, with TVA pursuant to EPA's authority under the Comprehensive Environmental Response Compensation and Liability Act, CERCLA, under which TVA will continue to perform the response action with EPA oversight. The EPA AOC with TVA does not replace the Tennessee Department of Environment's order, which remains in effect. EPA's working relationship with the State of Tennessee has been exceptional and we will continue that partnership.

Under the AOC, response actions will take place through time critical and non-time critical removal actions. The AOC will help ensure that the cleanup is comprehensive, fully transparent to the local community and public, and meets all Federal and State environmental standards. A principal objective of the time critical phase of the removal is to recover the major portion of coal ash in the Emory River to help minimize the potential for flooding and downstream migration of the coal ash.

Under the Tennessee Department of Environment's order and the EPA AOC, TVA was required to perform a detailed analysis of off-site disposal options for coal ash removed from the Emory River. That effort resulted in the selection of the Arrowhead Landfill in Perry County, Alabama as the best off-site facility to receive the coal ash generated from the time critical removal action. The landfill is fully lined and meets all technical requirements specified by State and Federal regulations.

Another important factor in the selection was the preference for rail transportation. Rail transportation greatly reduced the potential for vehicle accidents, avoids local traffic burdens, and is approximately three times more fuel efficient than truck transportation. After a thorough review, EPA approved the selection of the Arrowhead Landfill.

As stated in previous testimony provided to the Subcommittee, the failure of the ash impoundment at TVA's Kingston plant highlighted the issue of impoundment stability. EPA is currently conducting an assessment of impoundments and other management units which contain wet handled coal combustion residuals. We are finalizing our review of the responses to the CERCLA 104(e) letters that were sent to facilities. Overall, the assessment responses are from more than 200 facilities which have identified more than 500 management units. We expect to post that information on the EPA website within the next six to eight weeks.

In the meantime, EPA staff and contractors are in the field conducting on-site visits and inspections of those management units reported as having a high or significantly high hazard potential while also reviewing any current dam safety reports available from States or the facilities. Our goal is to complete all of the assessments for dams with high and significant hazard potential ratings this year.

As to TVA's root cause analysis of the Kingston facility failure, EPA staff have reviewed the currently released analysis report which identifies some of the factors that could have contributed to the Kingston facility structural failure. EPA contractors are looking for structural stability factors in our ongoing impoundment and management unit assessment efforts. Some of the factors being looked for include the size, age, and location of the structures; size of dam or dike erosion; settlement, cracks, or other signs of deterioration; seepage or leakage; and site soil, groundwater, and surface water characteristics.

In addition, EPA is evaluating coal ash residual disposal practices at coal fired power plants to determine if these facilities are in compliance with existing Federal environmental laws. We will take enforcement action where appropriate to address serious violations.

Madam Chairwoman, that concludes my prepared remarks. Either I or Stan Meiburg will be pleased to answer any questions that you or the Subcommittee Members may have. Thank you.

Ms. JOHNSON. Thank you very much.

We will now hear from Mr. Kilgore.

Mr. KILGORE. Madam Chairwoman, Ranking Member Boozman, and Members of the Committee, thank you for the opportunity to update you on TVA's progress in the recovery of the Kingston Fossil Plant spill. We appreciate the Committee's oversight. Madam Chairwoman, we appreciate your visit to the site last June.

We are working hard to rebuild the pubic trust. We know that that is going to be a difficult task but we are working to make sure that nothing like this happens again.

When the event happened, I knew we had to do many things. I am here today to talk about what we did on root cause and to ensure that our other facilities were safe. I knew we needed technical answers about why Kingston happened, but even more urgently we needed to find out about our other sites.

To get those answers, we commissioned two internationally recognized and respected engineering firms. AECOM was brought in to conduct the root cause analysis of Kingston and the spill itself. Stantec, another firm, was commissioned to evaluate the structural

integrity of all of TVA's other ash ponds. We used two different firms because of the urgency of the situation and the size and the scope before each firm.

As you will hear shortly from Mr. Walton, AECOM's extensive forensic investigation determined that four long-evolving conditions, some existing since the 1950s, caused the event. I will also address the management and system factors that contributed to that. We have carefully studied AECOM's report and accept Mr. Walton's thorough and well documented assessment.

As AECOM was conducting its work at Kingston, Stantec was busy at TVA's other sites with their technical evaluation. Starting in January, Stantec began to inspect, test, and make recommendations on our other facilities. We have worked aggressively over the last six months to implement their recommended changes.

I also wanted us to take a self-critical approach in looking at the hazard classifications of the storage impoundments. We were not among those 44 that were originally listed. I recognize that and we moved to correct that. Although we don't have any indication of these structures being in danger of failing, we have reclassified impoundments at four of our sites as having high hazard potential. We are prioritizing our efforts at those sites.

In order to fully understand what happened at Kingston, we needed also an analysis of TVA's organization and culture. The TVA Board of Directors commissioned an independent investigation to examine and identify possible management and organizational factors that may have contributed to the Kingston spill. That work began in January. The investigation was led by the international law firm of McKenna Long & Aldrich.

The MLA investigation that was presented to the Board by MLA last week and released publicly did identify shortcomings and missed opportunities in our organizational effectiveness and our accountability. At the Board's direction, we are already moving quickly to remedy these shortcomings. I have initiated an agency-wide organizational effectiveness plan focused on culture change and improving our systems, standards, controls, and accountability.

I am pleased that MLA report recognized that we are making some significant remedial progress to prevent any future pond spills. But I also want to tell you that I heard the word of caution that a comprehensive directive needed to provide assurance that best practices would be sustained across TVA, owned by senior management, and under the Board's oversight.

Last week I described the results of the MLA investigation to our employees as tough medicine. It is hard to take, but tough medicine will make us better.

Today we have the benefit of the report done by the Office of Inspector General. Mr. Moore will testify on that shortly.

All four reports from AECOM, Stantec, MLA, and the Inspector General will help us address both the technical and cultural issues that contributed to the Kingston spill. Importantly, these reports will be our road map going forward both to strengthen the integrity of our facilities and to forge a culture of accountability at TVA. Madam Chair, my written testimony to submit to the Committee provides more details.

While we have much more to do, with the Chair's permission I would like to give you some idea of the progress we are making. We have a long way to go but I would like to show some photographs.

This is the picture of the ash spill as it looks today. This is what it looked like shortly after the event. You can see the river is filled. We estimate that about three million cubic yards were beyond what we called Dike 2. As we have dredges in, we now have removed about a half a million cubic yards of that material and are continuing to work.

This is what the railroad and the road looked like the day after the event. We have that restored and that road is open to the public.

One of the sloughs nearby, this is a minor slough that we call Church Slough. You can see that it was filled with ash. This is an example of what we have to do for the rest of the site.

As I said, we have a lot of work to do. We are not finished by a long shot. We look forward to continuing to work with the Committee as we move forward.

Ms. JOHNSON. Thank you very much, Mr. Kilgore.

We will hear from Mr. William Walton now.

Mr. WALTON. Good morning, Madam Chairwoman and distinguished Members of the Committee. I appreciate the opportunity to share with you the results of our five month investigation of the root causes of the Kingston failure.

On the morning of December 22nd, 2008, a massive flow side occurred. Within one hour it inundated the Watts Bar Reservoir, several sloughs, and spilled over onto private properties. There were no witnesses to the failure because it was nighttime. No one knew where it started or how it happened. Our assignment was to answer these questions and to determine the geotechnical causes of failure.

We have conducted a thorough and comprehensive forensic investigation and root cause analysis presented in ten volumes with more than 5,400 pages. This RCA process involved frequent input from TDEC; the TVA OIG and their consultants; the U.S. EPA; the Bureau of Reclamation; the insurer's geotechnical engineer; and the independent peer reviewer of Dr. Gonzalo Castro, an elected member of the National Academy of Engineering. We did this to ensure that they would all be fully informed of our discoveries and progress as analyses evolved. We met on eight separate occasions to share information and to refine the analysis methodologies.

Our written testimony offers lessons learned that can be applied to other wet ash disposal facilities. I will show you several slides from the testimony that I have submitted that illustrate the failure sequence and the controlling factors. Due to the time allotment, I will go through these slides briskly. However, I invite your questions on any information that we have shared with you.

This is a photograph from April of 2008 showing the confinement, the dredge cells, and the ash collection pond. Within six months, this tragic and catastrophic failure occurred, discharging more than two thirds of the contents above the ash collection pond.

I will show you our opinion on the causation. We are looking from northwest to southeast. We believe failure began in the north-

west corner, originating as a deep seated failure internal to the exterior confinement. Like a pie coming out of a pie plate, this material heaved out within a very short time frame and surcharged the perimeter containment system, causing a overload on the outboard containment. That caused that outboard containment to breach, making the liquid contents liquify and flow out. From a 3H:1V slope this flowed out to an angle of repose less than one half degree.

I will show you a few historic photographs to see the progression of this site. In 1949, this was a lake making up the Watts Bar Reservoir created in 1942. The dotted red line indicates the outside containment system hopping from island to island. Note that for the first three or four years of operation, from 1954 to 1958, the ash was released directly to the waters of the Watts Bar Reservoir. This system was firing power to Oak Ridge as a national defense facility.

By 1958, the containment pond was established. Here again I will show you in green the distance that ash from the plant would have to travel for waters to be released back to the reservoir. It was over 5,200 feet, a mile. This ash would collect from the coarsest grains on the south to the most fine grains on the north. As we progress with time, this eventual ash pond was eventually filled in and the material was stacked.

In 1984, in an effort to provide more material within the confines of this containment system, a dredge cell super elevated above the ash pond was created to store more material as the plant operated.

By 1996, engineering plans were done to expand the facility vertically.

By 2005, this photograph shows you the three cell system that was collecting ash was now down to two. The footprint of the disposal was getting smaller but the structure was getting higher. Notice in red is the 2003 slide event where seepage in piping occurred.

We looked at 12 failure modes at this particular site identified in our work scope in late December and early January. We then evolved to four controlling factors. It is too hard to read all of these but these are a part of the testimony that are included in the slides.

The point of fact is that this structure, on its way to be built to the year 2014, did not make it to its ultimate height. The red line demarks its failure.

The underneath foundation is shown to be a material of the finest grains that had traveled the furthest early on in the progression of this particular disposal facility. It is a slime, a mining term meaning a material that travels the farthest, that drops out at the last, being the finest, loosest materials accumulating on the bottom. Those slimes were found in the upper portion, the northernmost portion, at the furthest distance from its deposition.

Again, it was an issue of finding these with an extensive exploration program. We were able to see the slide plane and identify these slimes through undisturbed sampling. We were able to analyze the stability of those sections that failed on the north as well as those sections that did not fail to the east or were consequential to failure on the west.

I will take you very quickly through the progression of failure in cross section as you would look west. The early portion would fail like the pie I explained. That material would surcharge over the initial containment dike, causing it to be overstressed and breached. Notice the issue on the right side. The flood wave from this event was a 47 foot flood wave above the operating pool, clearly a very dramatic failure in a very short period of time, resulting in the release of the materials.

This leads us to the conclusion of four controlling factors or failure modes that led to this: The load was impacted by the ever increasing height and the constant force of ash. The containment system was discontinuous and separated. That laid on a foundation, and the foundation serves as the footing for the building or home or whatever. The foundation is important. If those three elements are weak and you contain a loose, wet, liquefiable ash and lose your containment, it then can be released in a very dramatic manner, 5.4 million yards.

Thank you very much.

Ms. JOHNSON. Thank you very much.

Mr. Richard Moore.

Mr. MOORE. Good morning, Madam Chairwoman Johnson, Ranking Member Boozman, and Members of the Subcommittee.

I am TVA's Inspector General, having been appointed to this position by the President in May of 2003. Prior to becoming the first Inspector General appointed by a President at TVA, I was a Federal prosecutor in the southern district of Alabama for approximately 18 years.

It is a pleasure to be able to testify here today about the Office of Inspector General's review of the coal ash spill at TVA's Kingston Fossil Plant in December of 2008. I believe you have a copy of our report which, as you mentioned, is becoming public today.

Mr. MOORE. The Kingston spill has brought intense scrutiny upon TVA, as is well known, and with it a call for more oversight of the agency. The conditions at TVA that led to the disaster of December 22nd, 2008 have existed for decades. It is unfortunate that it has taken this kind of incident to prompt changes.

The TVA culture at fossil plants relegated ash to the status of garbage at a landfill rather than treating it as a potential hazard to the public and to the environment. We believe this culture resulted in management failures which contributed to the Kingston spill.

Our report points out a number of issues that I would summarize into basically three categories. First are the warnings and red flags. Those warnings and red flags were raised by outside consultants and internal staff but were simply not addressed. Number two, there was an inadequate system of management controls as evidenced by fragmented organizational structures, a lack of policies and procedures, and inadequate training for dike inspectors. Number three, there were poor management practices that included a lack of maintenance of dikes and overall poor communication between organizations. Our report provides a more detailed discussion of each of these items.

Madam Chairwoman, you have said that the Kingston spill was caused by regulatory neglect, a lack of Government oversight, and

irresponsible coal ash practices. Our report that we make public today supports your statement.

TVA management knew, for example, that consultants had been hired by them and had urged them to perform a much needed analysis and to take specific corrective actions. TVA management knew that they had failed to follow the engineers' recommendations and that they had failed to perform the analysis or take the corrective actions. TVA's management also knew that it had a history of poor maintenance of its ash ponds and that it had experienced seeps or breeches in the past. Finally, TVA management knew that there were no policies or procedures for the management of coal ash. Documents supporting what I have just said are a matter of public record, have been made available by TVA through litigation. These facts are widely known.

The TVA Board appears to clearly understand the gravity of the situation. Recently they have taken bold steps to address the problems that we have identified in our report. Also, although TVA management was slow to publicly discuss management failures, as we point out in our report, I am pleased to say that they have made great strides in starting a long process to not only rebuild the ash management program but to attempt to rebuild the trust and respect of Congress, the American people, and TVA's many stakeholders.

This will not happen without continued oversight by this Subcommittee and other oversight authorities including that of the Office of Inspector General. We are committed to devoting resources to monitor TVA's new commitment to transparency and accountability. We welcome your support in that endeavor.

In addition to the recommendations in our report, the Office of Inspector General recommends that Congress hold regular oversight hearings to determine number one, whether TVA's coal ash facilities have either been closed properly or modified to an appropriate safety level; number two, whether TVA's culture has in fact been changed to become more transparent and more accountable; and finally, whether TVA has fulfilled its responsibilities to the citizens of Roane County to clean up their community and to make them whole.

Madam Chairwoman, this concludes my opening remarks. I look forward to answering any questions that you or the Committee may have.

Ms. JOHNSON. Thank you so very much.

Mr. William Almes.

Mr. ALMES. Good morning. Madam Chairwoman Johnson, Ranking Member Boozman, and Members of the Subcommittee, my name is William Scott Almes. I am the Director of Geotechnical Engineering for Marshall Miller & Associates. I am a licensed professional engineer with a Bachelor of Science and a Master of Science in civil and geotechnical engineering. I have worked in the field as a consulting engineer for nearly 20 years.

I was the lead project manager on a peer review of the study commissioned by TVA to determine the root cause of the December 22nd, 2008 ash spill at TVA's Kingston Fossil Plant. I appreciate this opportunity to testify before you regarding the results of that peer review and other observations about ash management prac-

tices at TVA. We prepared this work for the TVA Office of Inspector General. The details of it are incorporated into their report that is being made public today.

I will now summarize the results of our work focusing on three important topics. First is Marshall Miller's conclusions regarding the root cause analysis. Second is our general conclusions and observations of ash management practices. Third is our recommendations for moving forward.

Our first conclusion regarding the root cause analysis is that, in Marshall Miller's opinion, the four probable root causes identified by AECOM are technically plausible, reasonably supported by the data, and that all four contributed significantly to the spill. However, Marshall Miller believes that the AECOM root cause analysis focuses disproportionately on the significance of this thin, discontinuous soft foundation layer, which has been called a slimes layer or sensitive silt layer, as one of the most probable root causes.

The significance of the "fill geometry" and the "loose wet ash", in other words, hydraulically placed or sluiced ash, indicate these factors also as probable root causes of equal or greater significance to the soft foundation soils factor. They should be equally emphasized. In Marshall Miller's opinion, the failure was not strictly associated with the thin, weak, sensitive silt and slimes foundation layer and more associated with the ash dike geometry and the relatively low strength of this sluiced loose wet ash and impounded material.

Lastly, this has significant implications for TVA and the power industry. Other similarly constructed TVA impoundments with or without the slimes layer could be at risk of failure and should also be investigated.

I will now focus on our general conclusions and observations concerning ash management. As early as 1985, intrinsic problems related to the stability of Dike C, which is the original dike, were known by TVA. An internal memorandum included in our report indicated that the calculated factor of safety for stability was less than the minimum accepted value of 1.5. Close monitoring was recommended at that time to detect any potential signs of failure in lieu of changing TVA policies and procedures that would require that the ash pond be designed to a higher dam safety standard. No specific action by TVA appears to have been taken to improve the stability of the earthen Dike C embankment.

In Marshall Miller's opinion, if TVA had included its ash ponds in a dam safety program, as discussed in the December 1988 memorandum when TVA decided against this policy, the probability of identifying some or all of the conditions that led to the failure would have increased significantly.

The construction of successive upstream stages to an elevation of 820 feet, which is the approximate failure elevation, above the original containment dike may have contributed to an additional decrease in the factor of safety of the containment dike system. In essence, at the time of failure, this increase in constructed height was approximately 70 feet higher than the original crest elevation of Dike C.

The design of the Kingston coal ash dredge cells should have included a thorough engineering evaluation of all potential failure

modes. Our recommendations for moving forward is that, since in our opinion, the Kingston ash pond failure was not strictly associated with the thin, weak sensitive silt and slimes foundation layer and more associated with the ash dike or fill geometry and the relatively low strength of the sluiced wet ash, other similarly constructed ash impoundments could be at risk of failure and should be properly investigated.

TVA and the power generation industry as a whole should strongly consider all the factors evaluated by AECOM as probable root causes of the Kingston failure when assessing the condition and structural integrity of wet ash disposal facilities. It is not prudent to presume that, if slimes observed in the failed section at Kingston do not exist at any other sites, there is adequate stability of these structures. On the contrary, the information developed from the extensive studies conducted by Stantec and AECOM indicates that there is reasonable risk of other dike failures if changes are not made in the design, construction, oversight, and operation of these facilities.

Lastly, sound engineering practice is to design such facilities with features that provide a reasonable degree of redundancy or a second line of defense in the event that one or more of these systems become inoperable. It is important that this design philosophy be applied to all of TVA's ash disposal facilities.

This concludes my statement. I look forward to answering any questions you may have. Thank you very much.

Ms. JOHNSON. Thank you very much.

We will begin the first round of questions now.

Mr. Kilgore, first of all, thank you for the pictures of the cleanup of Church Slough. I am really delighted and pleased at what this remediation of the Kingston spill can look like once it is all clean.

As you noted in your testimony, I have traveled to Kingston and have seen the spill firsthand. Not 500 feet from the area shown us in the photographs is another contaminated area known as the embayment. Can we get a commitment from you today that you will restore that greater area to the same standards and the same conditions as you demonstrated is possible in the Church Slough?

Mr. KILGORE. Yes, ma'am. We have made that commitment that we will clean up the river first, as the EPA has testified. Then we will move to the embayment. Then we have to move to the failed cell itself and fix that. So we have really three areas. We are committed to fix all three of those areas.

Ms. JOHNSON. Now, you have seen this. I don't know how long it took for the buildup to come but have you determined how often you might need to move this out to keep it from accumulating to that level again?

Mr. KILGORE. How often we might need to move this ash?

Ms. JOHNSON. Yes.

Mr. KILGORE. Yes, ma'am. We are designing a dry collection system there. That ash will have to be stored off-site. We intend to dry all of those ponds out so that we do not have wet storage on-site. As we move forward with that, as we design and implement that dry collection system, I anticipate all the ash will be transported off-site.

Ms. JOHNSON. I understand you are moving it now to Alabama?

Mr. KILGORE. We are.

Ms. JOHNSON. Is that going to be a permanent place that you may be able to take it?

Mr. KILGORE. No, ma'am. I wouldn't say that. We solicited bids from all locations that had the proper permits. We got several responses to that. We selected the site we did because, after we tentatively looked at that, I sent two of my senior executives down to look at it and talk to the community. They made sure that they were ready to receive it, that the pond and the permit looked in order, and all of that. Then we asked EPA for approval to ship that. We have committed to ship about three million tons out of the existing 5.4 million that we need to recover. We will be continuing to look at other sites for shipment.

Ms. JOHNSON. Thank you very much.

Mr. Stanislaus, in your testimony you state that EPA continues to evaluate coal ash disposal practices at coal-fired power plants to determine if these facilities are in compliance with existing environmental laws. Would you provide us a summary of the findings so far? Please also speak to compliance with Clean Water Act discharge permits.

Mr. STANISLAUS. We are in the midst of doing the assessment. We expect to complete the assessment of the high hazards and significant hazards by the end of this year. When we complete that we will certainly provide that to the Committee and yourself.

Ms. JOHNSON. Now, let me just ask this one last question to you. In your view, from both storage and water quality perspectives, should coal-fired power plants be using wet ash disposal methods or dry?

Mr. STANISLAUS. Clearly, the use of wet ash is a significant risk that we are looking at in terms of our rule making. It has been identified as a risk of impact to groundwater and water quality. That is something that we are taking a hard look at in terms of our rule making, which we will be completing by the end of this year.

Ms. JOHNSON. Do you plan to modify your oversight with TVA in view of the Inspector General's testimony?

Mr. STANISLAUS. TDEC, the Tennessee Department of Environment and Conservation, has a local lead of that. We are working with TDEC in terms of its oversight. We are in the field in terms of overseeing the removal of the coal ash from the river. We will be there throughout the removal of the coal ash.

Ms. JOHNSON. Yes, but I mean in general. I also would like to say, too, that until EPA really got involved, according to the people in the area, they didn't see much change. What kind of oversight will be performed by those persons that have that responsibility?

Mr. STANISLAUS. EPA is on the site every day overseeing the work.

Ms. JOHNSON. They are now?

Mr. STANISLAUS. Yes, they are.

Ms. JOHNSON. Thank you very much.

Mr. BOOZMAN. Thank you, Madam Chair. Mr. Moore, you mentioned that you agreed with the statement about poor oversight and lack of regulation as a contributor. I guess my question is poor

oversight from whom? Is it the State or EPA? Your Office plays a role in this.

Mr. MOORE. Certainly, as you are aware, the Kingston facility was licensed or permitted as a landfill. There is a question about how adequate that regulation was. There is also a question, and I believe Mr. Walton FE

Mr. BOOZMAN. In regard to that regulation, whose fault is that?

Mr. MOORE. I don't necessarily want to pin fault, but I would say FE

Mr. BOOZMAN. But that is your job.

Mr. MOORE. Well, TDEC certainly was the regulating authority. The question would be whether there should be other regulators on these types of facilities. Certainly if they were regulated as dam structures, as I believe both Mr. Walton and Mr. Almes would recommend, there would have been more strenuous examination. If that had been done in this case, I am reliably told by Mr. Almes from Marshall Miller that it is possible that the Kingston spill would not have occurred.

Mr. BOOZMAN. So EPA was doing their job?

Mr. MOORE. Well, I don't know what EPA's jurisdiction would have been over a landfill at the time.

Mr. BOOZMAN. You mention that lack of regulation. Was it lack of regulation or just failure to enforce the current regulation? I think that is important. I don't know. That is why we are asking these questions.

Mr. MOORE. My observations, sir, would be that even strict regulation of a landfill, when you have the combined geotechnical forces that were at work here, would not have been sufficient.

Mr. BOOZMAN. Very good. Mr. Kilgore, what steps is TVA taking to ensure that this doesn't happen at the other coal ash storage facilities? In particular, I know TVA utilizes wet ash storage at other sites, some of which are no longer in operation. While TVA is proposing to close the five operational wet coal ash disposal sites, what is TVA proposing to do with those sites that are no longer in operation?

Mr. KILGORE. We have one of those sites, sir, at the Watts Bar Fossil Plant. We have contained it. The other five sites that are wet storage, besides Kingston, we are moving forward with a plan to take all of those to dry storage. So we are going that way.

What we have done in the last six months is Stantec's identification. They walked down all the facilities and they identified initial issues that we needed to correct. We have hauled about 82,000 tons of rock to shore up various places. We have cleaned out vegetation so that the inspectors can see better. But I think the most important thing is that we have gotten a lot more intrusive. In other words, instead of doing visual investigations, we have drilled holes. Stantec has gone out there much like AECOM did on the failed facility and drilled into these dams to ascertain what is underground so that they know what is underground. That gives us some more comfort but we will not be comforted until we know exactly what is down there and we take all the remedial actions. We have tried to unstop all the drains to make sure the drains are properly operating. We have tried to backfill, as I said, with stone. We put

piezometers down, about 250 piezometers in these ten other sites, so that we can see movement and see water.

Mr. BOOZMAN. Very good. I have one final question, Mr. Walton, real quick. When you all were contacted to look into this and figure out what was going on, the root cause, were you just asked to do the technical aspects of it or did you get into the corporate culture and things like that? Were you asked to do both?

Mr. WALTON. No. Our role was the technical review of the root cause for failure, the cause location and explaining the failure mechanism.

Mr. BOOZMAN. Okay. Thank you all very much. Thank you, Madam Chair.

Ms. JOHNSON. Thank you very much. Mr. Griffith.

Mr. GRIFFITH. Thank you, Madam Chair. The EPA initiated a report in 2002 that has just been released in 2009 that demonstrates the carcinogenic effect of coal ash combustion material from coal. Are you familiar with that report release in 2009?

Mr. STANISLAUS. I am not specifically familiar with it.

Mr. GRIFFITH. Let me tell you a little bit about it. In 1775, a year before 1776, Dr. Percival Pott described coal combustion causing cancer in chimney sweeps. We have known for that many years that these were carcinogenic agents that we were producing. We have noted that all through the subsequent years. In 2009, a report was issued that had been ongoing since 2002 within your agency. It demonstrated that the increased risk of cancer around these coal ash deposits was significant.

My question is this: Do you believe that, had you told Mr. Kilgore about those findings, there would have been a heightened responsibility on the part of TVA? This dump in particular was unlined and leaking into the goundwater. As far as EPA is concerned will this spill have far reaching consequences? The second part of that question is how are you going to know when you have got that site cleaned up, if a great majority of it has already gone downriver?

Mr. STANISLAUS. With respect to your first question, clearly this spill is a catastrophic event that should not have occurred. Clearly the constituents in coal ash are something that we are taking a look at in terms of regulation. We will be issuing that regulation later this year. So we are taking this seriously, the consequence of the constituents in that.

With respect to knowing when we are done, that is frankly our job. We have historically remediated river sites. We will ensure that everything is removed from the river.

I don't know if Mr. Meiburg wants to add to that.

Mr. MEIBURG. I would only add to that, Congressman, that fortunately, or unfortunately depending upon your point of view, most of the material actually stayed in some vicinity of the site. Our highest priority on the cleanup has been to get the material out of the main stem of the Emory River to make sure that more doesn't go downstream, especially during the spring flood period. That is why we have been pushing to accelerate the removal of the material from the river, so that we could try to get most of it out of the main stem before next spring. We have been making accelerated

progress on that with TVA over the last couple of months. We expect to continue that.

Mr. GRIFFITH. Thank you. This issue really is not, I am changing gears a little bit, this issue is really not about cleanup. Mr. Almes, I think you were probably not surprised at the spill after being an engineer and inspecting. I don't think anyone is faulting anyone on the cleanup. What we are concerned with is the multitude of areas in the country that are very similar to Kingston. I know that you have had that experience in Iowa. We have had that experience in Pennsylvania.

We do know that this coal ash is as carcinogenic as nuclear waste. We know that arsenic, selenium and boron are chemicals that we are finding in the waste. And we know that they are now present in the drinking water in many communities. How can we reassure our constituents? Since the Tennessee River runs through my district, how can we reassure my constituents that they are safe, that we are keeping them safe?

Mr. STANISLAUS. I presume that is directed at me.

Mr. GRIFFITH. Well, anybody can chime in on that one if you have got a good answer.

Mr. STANISLAUS. As Administrator Jackson has committed, we are going around the Country and doing an assessment of all facilities with high and significantly high hazard ratings. That will be done by the end of this year. We will also be taking a look at all of the facilities to assess where there is any risk of failure and prevent that. Also, if there are any violations, we plan to do enforcement actions. Those are the short term actions. We are simultaneously looking at the risk and the need to develop some rules to prevent any impact to groundwater or surface water.

Mr. GRIFFITH. This is just for Mr. Kilgore. My question is whether we should rely on State agencies? Should we punt the responsibility to a State agency that apparently has failed us in this area as far as inspections?

In your organization, and I know you are new to the job, essentially, and inherited a great deal of this, are heads rolling? Are you getting anybody's attention there? TVA is like turning around the Queen Mary. This will take a while. What can we look forward to there?

Mr. KILGORE. Well, we have to change. If that means heads have to roll or people have to leave, so be it. You would find, if you go back from when I arrived until now, that about two thirds of the senior management has changed. About 90 percent of the plant managers have recently been rotated or, in some cases, new plant managers have been installed so that we have new eyes on this problem.

If I have learned one lesson about this, it is to be intrusive and to be self-critical about things we don't know about. That means that occasionally we need fresh eyes on the subject and that we don't allow these waivers, if you will, from looking at things.

I will be honest, the memorandum that was mentioned earlier in 1985 said that the safety factor was not what it should be. But further down it said that the remedy is a daily inspection. That is not good enough. Knowing what we know now, it is not good enough that the remedy was a daily inspection. The safety factor has to be

increased. We are the first line of defense on that and we have to do that.

Mr. GRIFFITH. I have one last thing, Madam Chair. I am over time but I am concerned that we might be allowing TVA to grade its own paper. In an agency that big, I know that you can't sit there and watch them take the test. So my concern is that grading your own paper is a great danger to us. Should we have random independent inspections of facilities outside of the TVA organization?

Mr. KILGORE. I think that is a question more to our regulators, EPA. But I will tell you that we welcome the outside. I have learned a lot in this. I don't think we are grading our own papers since I have got EPA, TDEC, the OIG, and an outside law firm that the Board employed. I have got four people looking over my shoulder. We have put over 20,000 pages of documents on the website so that everybody else can see that. Some of those are very painful for me. I am both saddened and frankly a little bit mad that I walked into this. But it is my responsibility now that we have found it to clean it up and to change the culture.

Mr. GRIFFITH. Thank you, Mr. Kilgore. Thank you, Madam Chair.

Ms. JOHNSON. Thank you very much. Mr. Hare.

Mr. HARE. Thank you, Madam Chairwoman. Mr. Kilgore, in early July after the release of the root cause analysis by AECOM, the TVA released a statement that included the following statement. It says, "TVA has asked Stantec to pay particular attention to the four major contributing causes of the Kingston ash spill to ensure the combination does not exist at any other site. To date, nothing has been found that indicates that this combination exists at other TVA facilities."

Based on the earlier statements by Mr. Walton and Mr. Almes, I wonder if you could explain the public statement by TVA? In my view, this seems to imply that because that particular combination does not exist, there is no viable threat of collapse at these other facilities. I was wondering, do you share that same plain reading interpretation?

Mr. KILGORE. I do not share that interpretation. Thank you for asking that question. We obviously, since those four factors were identified, pay particular attention to them because I don't want any of those four factors to catch us again. Stantec has been debriefed regularly by AECOM so that they know what is going on. But they have not been limited to that. What we are concerned about is that all the rest of these structures, frankly, may be individual. None of them may be like the other ones. So we have got to be, as I said earlier, intrusive in each one of them.

AECOM drilled many, many holes. They even asked us to cut a slice in the old dike at Kingston so that they could see what was really down there. We are asking Stantec, they have already started doing that and they have completed quite a bit, to put those instruments down there.

So the implication that if these four factors don't exist elsewhere we are home free is not an implication that I agree with. We have to treat each one of those as its own individual structure.

Mr. HARE. In your testimony today you state, "There is no evidence of imminent failure at other TVA sites based on initial Stantec evaluations." However, in its recent Phase I assessment report, Stantec itself states, "Due to limited record drawings and construction QA/QC documentation at any of these facilities, Stantec is unable to render opinions relative to overall structural integrity." These two statements seem to be wildly inconsistent.

So, especially in light of the findings by the McKenna and the TVA OIG reports concerning a broken culture of accountability, this seems very troubling. Can you maybe comment on this and enlighten me?

Mr. KILGORE. I will try. Let me address the Stantec report first of all. What I understand from that, in talking to them and others of my staff, is that when they looked at our drawings they indeed found this culture problem. We had the drawings of how the dams were supposed to be built but they didn't have as-builts. So we didn't know what was changed and we didn't know if they were built according to those drawings. That is why we asked them to go be intrusive, to drill, to find out everything they could about the as-built condition.

So, yes, they can't give me an unequivocal statement that this is not in danger of failing. What we are doing is following their advice, letter by letter, and trying to go frankly a little overboard with some of it in terms of our clearing and our progress toward drying it out.

As I said earlier today, I will not be comfortable until we have the knowledge of what is underground on all of these. Stantec has a few months yet to work on this to complete their work. Even then, I think we still have to be self-critical and intrusive.

Mr. HARE. I have just one last question, maybe for the panel. I apologize because I came in late. What was the total cost of this cleanup to the American taxpayers? What was the total cost?

Mr. KILGORE. The total cost, we estimate, will be right at $1 billion.

Mr. HARE. $1 billion?

Mr. KILGORE. $1 billion.

Mr. HARE. Thank you, Madam Chair.

Ms. JOHNSON. Thank you very much. Congresswoman Napolitano.

Mrs. NAPOLITANO. Thank you, Madam Chair. Of great interest to me especially is the area of groundwater. Mr. Kilgore, I am under the impression that groundwater contamination was a problem before. Where there is a combination of dams and wet ash, is there leakage into an aquifer underneath that might contaminate aquifers in the area from which people drink?

Mr. KILGORE. We have no evidence that I know of that it is leaking into the aquifer. We have wells and we are monitoring those. So we have no evidence so far. I will let the EPA comment, but they commented also on the water and the intake structure. We have been monitoring FE

Mrs. NAPOLITANO. There is no lining.

Mr. KILGORE. Excuse me?

Mrs. NAPOLITANO. There is no lining underneath.

Mr. KILGORE. You are right. There is no lining. This ash, though, settles. The metals are not all soluble so it settles. We think it stays there, unless we have an incident like this. So our greatest need is to get all of this out of the river and back onto dry land so it can dry out.

Mrs. NAPOLITANO. Another area of concern, of course, is in the July 2009 report of TVA's Inspector General. Appendix C includes an internal TVA memorandum. Point four of this memorandum, "Because of concerns about groundwater contamination, TVA is moving away from wet ash disposal techniques to dry stacking." I would like to ask if you can provide the Subcommittee with copies of the analysis that went into formulating these concerns about groundwater in 1988, 21 years ago?

Secondly, in the 21 years since that analysis was presented to TVA management, what specific action or actions have been taken to alleviate TVA's own concerns about groundwater contamination?

I am into water. I am, you know, the Chair of the Subcommittee on Water and Power. So contaminants are something that we have been facing on my own Subcommittee. We have no new water sources. So any water that we abuse or misuse, we need to clean up.

I am concerned that any of these pollutants may have leaked into or contaminated the reservoir next to the Kingston facility. I don't know what EPA has done about making sure that contaminants are not being carried out to where effluent is being pumped out as fresh water.

Mr. KILGORE. Well, I am concerned about the water, too, because I live there and occasionally go boating. So I share your concerns. We do have wells in the area that we are monitoring. TDEC looked at 400 wells around the area and found no groundwater contamination. That is not a reason for us to rest. I take your concerns seriously and we are going to continue to look at that.

Mrs. NAPOLITANO. Would you provide this Committee, then, with the copies of that analysis that went into formulating that concern in 1988?

Mr. KILGORE. I will. Let me just admit that what the Inspector General found was that there was not proper action on some of those older things. I will admit that to you right now. That is what I have to change.

Mrs. NAPOLITANO. Thank you. EPA?

Mr. STANISLAUS. I will let Mr. Stan Meiburg deal with the local issues.

With respect to the impact on groundwater from impoundment, that is something we are looking at right now. That has been identified specifically as causing damage to groundwater and to surface water. We are looking at that in terms of developing new rules. Those rules will be developed by the end of this year.

With respect to the specific local concerns, I would like to let Mr. Meiburg address that.

Mr. MEIBURG. Yes. As Mr. Stanislaus said, groundwater contamination from these types of facilities has been a concern to EPA. Whether or not groundwater contamination occurs in part depends on the geological structure that underlays them. We have done pretty extensive sampling, along with the Tennessee Department of

Environment and Conservation, at this particular site. It appears that in this case we have been fortunate. There has not been migration of contaminants through a groundwater pathway in any of the samples that we have taken so far.

Mrs. NAPOLITANO. How often do you test those areas?

Mr. MEIBURG. We have been testing those areas very frequently now.

Mrs. NAPOLITANO. Frequently meaning daily, weekly, or monthly?

Mr. MEIBURG. No, we have not been doing daily samples. What we have done is gone and tested the wells, as Mr. Kilgore said, together with TDEC and TVA since the accident occurred. We have not yet found any movement into any of the wells that are tested. But it is not a regular sample. It has been a sample on request and demand.

Mrs. NAPOLITANO. I have a great concern about the cost to the general taxpayer, number one. Number two is the health and safety of those areas. Then, of course, number three is whether or not it becomes an issue that then comes back to the Federal Government to clean up. I have a contaminated site that has involved maybe 20 years in cleanup, costing millions upon million of dollars. The taxpayer is paying for it because the potential responsible parties are long gone.

I am certain that we don't want to face anything like that, maybe, in the other areas where you may have these same facilities. Steps must be taken to protect the water safety, the public safety, and any other area that is of concern. Mr. Kilgore?

Mr. KILGORE. Yes, ma'am. TVA does not get Government funding so all of this will fall to us to pay. Unfortunately, the steps that we didn't take in the past will now fall on our rate payers. We will have to pay for that through our electric bills. We intend to try to stretch that out. This problem didn't occur overnight so we are going to try to amortize that out over several years. Still, as you indicate, somebody has to pay for the oversights in the past. As I said, my job is to make sure it doesn't happen again.

Mrs. NAPOLITANO. Thank you, Madam Chair.

Ms. JOHNSON. Thank you very much.

Mr. Hall.

Mr. HALL. Thank you, Madam Chair. I am sorry for being late. I was double-booked, as many of us are. It so happens that I was at the Select Committee for Energy Independence and Global Warming where we heard, among other things, testimony from Dr. Brent Constantz, a professor from Stanford University and CEO of Calera Corporation, who talked about a potential future solution to this kind of problem.

I am just curious, Mr. Kilgore or any of the engineers, if you would comment on this CMAP technology, Carbonate Mineralization by Aqueous Precipitation, in which the natural carbonate mimics corals when they make their external skeleton, capturing CO2 emissions and storing it in a stable mineral form.

It can be used to replace or supplement traditional Portland cement, offsetting emissions that would otherwise result. It can be used as aggregate as well. The estimated current market demand

for cement and aggregate is over three billion tons per year in the United States alone and over 30 billion tons per year worldwide.

The process has the potential to provide a positive use of the overwhelming majority of U.S. coal fired emissions, including solid waste normally bound for landfills such as fly ash, luminous smelt, or byproducts such as red mud and other waste products that can be incorporated into this process. I know we need to solve this problem; we need to deal with the existing old technologies. But this seems to me like maybe a promising road for TVA to look at.

Mr. KILGORE. Yes, sir. I am not prepared to answer that today but I would like to have my research and development folks give me an answer for you and to file that for the record.

I will say that as to climate change, TVA approved about a year ago a goal to get us to less than 50 percent carbon-based generation by the early 2020s. So we are cognizant of the issue. This sounds like something that I would very much like our engineers to look into.

Mr. HALL. I will make sure you get a copy of it. We got all excited in the other hearing when we heard about this stuff.

I wanted to ask about specifically what actions, this is to EPA, what actions have been taken at TVA's Widows Creek, Bull Run, and Colbert power facilities? What enforcement actions has EPA engaged in? Why has EPA not enforced the Clean Water Act and other statutes as a result of this known pollution?

Mr. STANISLAUS. With respect to this particular spill, the Tennessee Department of Environment and Conservation entered into an order with TVA to address the cleanup. EPA subsequently entered into an agreement on consent to oversee the cleanup work by TVA.

With respect to Clean Water Act violations, I have to get back to you on that.

Mr. HALL. In the January 2009 Senate Environment and Public Works Committee hearing, Mr. Kilgore, you told Chairwoman Boxer and Senator Merkley that you would look into the groundwater and surface water contamination issues at these three facilities, cited by EPA. Could you tell us today how these facilities are implicated with the contamination of water? What exactly has happened? What steps have you taken and what are you looking forward to doing to deal with these facilities?

Mr. KILGORE. With respect to the three you talked about, I didn't find any evidence that we had exceeded any groundwater emissions there. We still plan on going to dry storage of the ash on those sites. So what we are planning on doing is getting rid of the wet storage there. That means that the water is less and the volume is less. The ash is stored in a dry state.

Mr. HALL. Thank you, Madam Chair. I yield back.

Ms. JOHNSON. Thank you very much, Mr. Hall.

I have one final question to Mr. Walton. You mentioned that there were lessons learned that are maybe applicable to other coal ash storage sites. Can you elaborate a little bit?

Mr. WALTON. I would be honored to. There is a body of knowledge that has been gained through the sampling of the loose wet ash. There has been an awareness as to the containment systems using the upstream dike methods of construction, similar in the

way that mine tailings facilities are done. There have been some lessons learned in that the ash does not improve its density with higher and deeper layers placed on top of it. I think that is applicable to be used and studied at other sites. Certainly the rate of loading is important as these sites get higher and higher with the added influence of gravity on these structures.

The lessons learned are that you don't have to have slimes. You might have a foundation system made of clays or you may be on some loose sands near an earthquake zone for those facilities near seismic areas. There are also the issues of piping and seepage and water management. These structures are made by hydraulic methods, controlling the waters that pass through and are contained. So there is water management, seepage management, storage, and containment. All these factors are lessons learned.

It is sort of an awakening in that trained engineers are able to get out there, inspect, assess, and take this program, through your guidance and others, forward so that this won't happen again.

Ms. JOHNSON. Thank you very much. Mr. Kilgore, what I would like to see is some communication between you and entities responsible for some of the other spills. See if you can come up with something of a plan for how often you have to move coal ash to prevent buildup. If you talk to Kentucky and some of the other places that have had similar issues, I would appreciate it.

Mr. KILGORE. I will do that.

Ms. JOHNSON. Thank you very much. This is the end of our hearing.

[Whereupon, at 11:55 a.m., the Subcommittee was adjourned.]

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Opening Statement
Rep. Anh "Joseph" Cao
July 28, 2009
Subcommittee on Water Resources and Environment
Committee on Transportation and Infrastructure

Hearing on "The Tennessee Valley Authority's Kingston Ash Slide: Evaluation of Potential Causes and Updates on Cleanup Efforts."

Thank you, Madam Chairwoman, for holding this important hearing. I will keep my remarks brief, but I do want to make a some comments to provide the parallels between this community's experience with that of my district.

In December 2008, a retention wall at Kingston's Fossil Plant failed, releasing 5.4 million cubic yards of ash and 327 million gallons of water onto the land and into the nearby rivers. The result of this failure was the release of 5 million cubic yards of coal ash into the Emory River and 300 acres of land being filled with sludge—in some places up to six feet deep.

This spill caused extensive disruption to the neighboring communities with evacuations and the loss of power and gas—not to mention the houses that were destroyed in the tidal wave of ash and water.

As the representative from New Orleans, I have great empathy for the communities that were directly affected by this unexpected and unprecedented event. I am also well aware of the effect failures in protective structures can have on surrounding communities. The damage to Orleans and Jefferson Parishes four years ago wasn't because Hurricane Katrina made a direct hit on New Orleans.

Instead, it was because the strength of the storm surge caused catastrophic failures in levees and flood walls throughout the city—especially in New Orleans East and the Lakeview area on the border with Metairie.

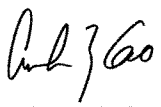
The damage from these breaches included flooding in 80% of the city, damage to 80% of the buildings, and damage to (if not destruction of) 40% of our housing stock. Because of these failures, the city remained underwater for days—and, in some places, weeks. But, as with the Kingston spill, the environmental hazards, were great. We all remember the images of the waters through which my constituents had to wade to get food and water. These were commonly referred to as a "toxic soup" because they were filled with sewerage, gasoline, and oil—to say nothing of bacteria and disease.

Like you, Madam Chairwoman, in the immediate aftermath of the catastrophic failures that occurred as a result of Hurricane Katrina, I sought accountability and assurances from the federal government—especially the Army Corps of Engineers—that repairs would be made to ensure such catastrophic failures never happened again. Through my work on this Committee and Subcommittee, I am closely overseeing the work of the Army Corps to ensure they are rebuilding our infrastructure to their former strength and beyond.

One of my priorities is ensuring the complete rebuilding of the 17th Street and London Avenue canals. Because of confusion within the Army Corps of Engineers, this requires assuring them they do have the authority to put in place the highest level of protection. I have co-sponsored legislation which reinforces this. I also continue to work with the Corps and my delegation colleagues to ensure this protection is achieved for my constituents.

Just like the community affected by the Kingston spill, my district can't afford another disaster.

Again, Madam Chairwoman, thank you for holding this important hearing, and I look forward to working with you as you continue your oversight of this important matter.



Anh "Joseph" Cao
Member of Congress

OPENING STATEMENT OF
THE HONORABLE RUSS CARNAHAN (MO-03)
SUBCOMMITTEE ON WATER RESOURCES AND ENVIRONMENT
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
U.S. HOUSE OF REPRESENTATIVES

Hearing on
The Tennessee Valley Authority's Kingston Ash Slide: Evaluation of Potential Causes and Updates on Cleanup Efforts

Tuesday, July 28, 2009
10:30 a.m.
2167 Rayburn House Office Building

Chairwoman Johnson, Ranking Member Boozman, thank you for calling this hearing on The Tennessee Valley Authority's Kingston Ash Slide: Evaluation of Potential Causes and Updates on Cleanup Efforts. I am pleased with the ongoing interest of this subcommittee in the underlying causes of the ash spill and I continue to offer my support during the cleanup effort.

Since the December 22nd ash spill in Harriman, Tennessee, we have seen various studies and assessments regarding the failure of the surface impoundment site as well as the immediate and more fundamental causes of this failure. While the TVA-contracted study—the Root Cause Analysis—emphasized an initial Dredge Cell failure and four conditions that combined to facilitate subsequent failures, it is clear that more fundamentally primary problems existed. While the AECOM assessment is beneficial as a first step, it is by no means the only step, as has been indicated by the recently released TVA Office of the Inspector General review. I am curious about the causal areas of divergence between the findings; specifically the factors that the OIG thinks were underrepresented in the initial TVA RCA study report, such as wet ash management practices and the inadequate construction of dredge cells and dikes. I hope that our witnesses will discuss specific details about structural inadequacies and improvements that can be made.

Along with the particular management and construction approaches, there are deeper underlying problems which eventually manifested themselves in the December 22nd ash spill. I would like to know more about the internal budget deficiencies of the TVA and the detrimental effects on necessary maintenance procedures, procedures which may have helped prevent this ash spill.

In closing, I'd like to thank the witnesses for their testimonies and presence here today. I hope that this hearing, along with previous hearings concerning these matters, will assist the Tennessee Valley Authority to shift from reactionary measures to preventative measures in order to avoid environmentally harmful incidents like this in the future.

OPENING STATEMENT OF REP. STEVE COHEN

House Transportation and Infrastructure Committee

"The Tennessee Valley Authority's Kingston Ash Slide:
Evaluation of Potential Causes and Updates on Cleanup Efforts"

July 28, 2009

- I greatly appreciate the opportunity to be here as the representative from Memphis, Tennessee as we examine clean up efforts for the Kingston ash slide.

MLGW

For Mr. Tom Kilgore (TVA):

- Memphis Light Gas and Water (MLGW), based in Memphis, serves 420,000 homes and businesses throughout Memphis and Shelby County. MLGW has brought to my attention concerns that their customers will see rate increases to cover the cost of the spill.

- Because MLGW is the largest of TVA's roughly 158 distributors and consumes about 10 percent of its electricity, MLGW customers could stand to carry a considerable portion of any rate hike instituted as a consequence of the clean up.
- In an April 27, 2009 response to an inquiry I made to TVA, Peyton T. Hairston, Senior Vice President of Corporate Responsibility and Diversity stated that they are exploring various avenues to find innovative ways to minimize adverse effects of the cleanup costs upon the ratepayers of our region.
- I would like to follow up on this issue and get some specific clarification from you:
  - Is TVA planning a rate increase on its utility customers to cover the cost of the clean up?
  - What are the different options TVA has explored for covering the costs of the clean up to date?

Allen Fossil Plant

For Mr. Tom Kilgore (TVA):

- TVA recently released a reassessment of its coal ash facilities for their hazard potential under dam safety hazard classifications. One of the facilities determined as a "significant" hazard potential was the Allen Fossil Plant, which is located in my district in Memphis, Tennessee.
    - What is TVA doing to assess the structural integrity of the Allen Fossil Plant, specifically?
    - How can my constituents trust that TVA is acting quickly enough to address its engineering designs and management practices so Memphis does not become the next Kingston?

Statement of Rep. Harry Mitchell
House Transportation and Infrastructure Committee
Subcommittee on Water Resources and Environment
7/28/09

--Thank you Madam Chair.

--As you know, this subcommittee has a responsibility to protect our nation's water resources.

--The coal ash spill at the Tennessee Valley Authority's (TVA) Kingston Fossil Plant put water resources at risk, and I believe it is appropriate for us to examine not only how and why this happened, but how we can avoid another such spill in the future.

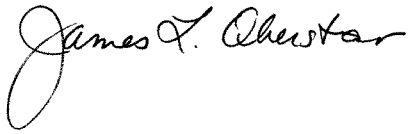
--This is the second hearing we have had on this issue, and thanks to your efforts, we now know a good deal more.

--However, questions still abound.

--The report from legal counsel retained by the Tennessee Valley Authority's Board of Directors is especially disturbing. Their finding that the necessary systems, controls, standards and culture to prevent a disaster like this were not in place is unsettling to say the least.

--I am eager to hear from today's witnesses.

--I yield back.



STATEMENT OF
THE HONORABLE JAMES L. OBERSTAR
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
SUBCOMMITTEE ON WATER RESOURCES AND ENVIRONMENT
HEARING ON: "TVA'S KINGSTON ASH SLIDE: EVALUATION OF POTENTIAL CAUSES AND UPDATES ON CLEANUP EFFORTS"
28 JULY, 2009

Madam Chairwoman, thank-you for holding this important hearing this morning.

This hearing may provide the Subcommittee with answers about what were the immediate triggers for the December 2008 Kingston coal ash spill. What is especially troubling, however, is that the testimony provided today raises more questions about why the failure occurred in the first place.

As demonstrated in reports from the Tennessee Valley Authority's Inspector General, as well as from the law firm McKenna Long & Aldridge, the management culture at TVA has resulted in a severe under-provision of adequate standards, operating procedures, and accountability for the handling of its coal ash operations.

The management, storage, and disposal of coal ash should not be thought of as an afterthought. This would be to – as TVA did for many years – treat it the same as one would garbage – something to be disposed of with little after-thought. This – as was amply demonstrated at Kingston – is a sizable miscalculation. Coal-fired power plants each produce thousands of tons of coal ash a year. The Kingston facility, for example, produced 1,000 tons a day! The sheer volume of this material – especially when it is transported and stored in a wet form – demands that it is treated with care. The storage practices for wet coal ash should be more akin to dam operation than to a landfill for garbage. This was not the case at Kingston – and it seems treating surface

impoundments as dams is not standard operating procedure across the entire TVA system.

The cavalier fashion that coal ash storage and disposal was treated at Kingston seems a function of both TVA's management culture, as well as the near complete lack of federal regulations regarding this matter. The McKenna and TVA OIG reports put forward a number of problematic findings regarding the impacts of TVA's management culture. These include, but are certainly not limited to:

- A TVA management culture that was reactive, and which did not deal with problems proactively;
- A lack of standards and training for operating and maintaining ash ponds;
- Inadequate budgets for prevention priorities;
- Recommended safety modifications were not made at multiple times in the past;
- Not applying risk management approaches to ash storage and disposal; and
- A management culture that treated ash like garbage – and not as a potentially lethal threat to the public and the environment.

These are serious findings that must be evaluated in greater depth by this Subcommittee. As important, they must be remedied by TVA.

These contributing human, or cultural factors, would seem to be central to the geo-technical factors that played roles in the Kingston collapse: loose wet ash, slimes, the height of the impoundment, and fill geometry and setbacks. While those four conditions were implicated in the Kingston spill, it seems that TVA is looking for this particular combination as it reviews its other facilities. The result? An absence of this

particular combination has been publicly held up by TVA as testament that their other surface impoundments are structurally secure.

In actuality, such statements are premature, and in that TVA is making them raises questions about its commitment to addressing potentially very real threats to the public and the environment.

As a federal entity, TVA must be held to a higher standard. As today's testimony makes clear, it is unknown whether TVA, itself, has the capacity or the willingness to make the type of changes that need to be made, itself. This Committee will continue to exercise all of its authorities – from oversight to legislation – to ensure that the proper changes are made at TVA to address its management shortcomings, and to ensure that it becomes the environmental steward it can and must be.

Statement of William S. Almes, P.E.

Director of Geotechnical Services
Marshall Miller & Associates, Inc.

before the

Subcommittee on Water Resources and Environment

of the

Committee on Transportation and Infrastructure

United States House of Representatives

Hearing entitled "The Tennessee Valley Authority's Kingston Ash Slide: Evaluation of Potential Causes and Update on Cleanup Efforts."

July 28, 2009 at 10:00 a.m.
Room 2167 Rayburn House Office Building

Good morning. Madam Chairwoman Johnson, Ranking Member Boozman, and members of the Subcommittee, my name is William Scott Almes and I am the Director of Geotechnical Engineering for Marshall Miller & Associates, Inc. I am a licensed Professional Engineer, hold a Bachelor of Science and Master of Science degree in civil engineering and have worked as a consulting engineer in the geotechnical engineering profession for nearly 20 years. I was the lead Project Manager on a peer review of the study commissioned by TVA to determine the root cause of the December 22, 2009 ash spill at TVA's Kingston Fossil Plant.

I appreciate this opportunity to testify before you regarding the results of that peer review and other observations about ash management practices at TVA. We prepared this work for the TVA Office of the Inspector General, and the details of it are incorporated into the Inspector General's report that is being made public today.

I will now summarize the results of our work, focusing on three important topics: Marshall Miller's conclusions regarding the root cause analysis; our general conclusions and observations of ash management practices; and recommendations for moving forward.

Marshall Miller's Conclusions Regarding the Root Cause Analysis

- In Marshall Miller's opinion, the four probable root causes identified by AECOM are technically plausible, reasonably supported by the data, and all four contributed significantly to the spill.

- However, Marshall Miller believes that the AECOM root cause analysis focused disproportionately on the significance of the thin, discontinuous, soft foundation layer (thin, weak, sensitive silt and slimes foundation layer) as one of the most probable factors/root causes. The significance of the "Fill Geometry" and "Loose, Wet Ash" (hydraulically placed/sluiced ash) indicate these factors as a probable root cause of equal or greater significance to the soft foundation soils factor/root cause and should be equally emphasized.
- In Marshall Miller's opinion, the failure was not strictly associated with the thin, weak, sensitive silt and slimes foundation layer, and more associated with the ash dike geometry and relatively low strength of the sluiced "Loose, Wet Ash" foundation and impounded material.
- This has significant implications for TVA and the industry. Other similarly constructed TVA impoundments, with or without the slimes foundation layer, could be at risk of failure and should be properly investigated.

Marshall Miller's General Conclusions and Observations About Ash Management

- As early as 1985, intrinsic problems related to the stability of Dike C were known within TVA. An internal memo indicated that the calculated factor of safety was less than the minimum acceptable value of 1.5 and close monitoring was recommended to detect any potential signs of failure–in lieu of changing TVA policies and procedures that would require that the ash pond be designed to the higher "dam safety" standard. No specific action by TVA appears to have been taken to improve the stability of the earthen Dike C embankment.
- In Marshall Miller's opinion, if TVA had included its ash ponds in the Dam Safety Program as discussed in December 1988 when TVA decided against this policy, the probability of identifying some or all of the conditions that led to the Kingston failure would have increased significantly.
- The construction of successive upstream stages to elevation 820 (approximate crest elevation of Dredge Cell No. 2 at the time of failure) above the original containment dike may have contributed to an additional decrease in the factor of safety of the containment dike system. In essence, at the time of failure on December 22, 2008, this increase in constructed height equated to an approximate 70-foot increase in the height of the ash pond above the crest elevation of the original Perimeter Dike C.
- The design of the Kingston coal ash dredge cells should have included a thorough engineering evaluation of all potential failure modes.

Recommendations for Moving Forward

- Since, in our opinion, the Kingston ash pond failure was not strictly associated with the "thin, weak, sensitive silt and slimes foundation layer" and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced "Loose, Wet Ash" foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.
- TVA, and the power generation industry as a whole, should strongly consider all the factors evaluated by AECOM as probable root causes of the Kingston failure when assessing the condition and structural integrity of wet ash disposal facilities. It is not prudent to presume that if the slimes layer observed in the failed section at Kingston does not exist at other plant sites, there is adequate stability of these structures. On the contrary, the information developed from the extensive studies conducted by both Stantec Inc. and AECOM indicates that there is a reasonable risk of other dike failures if changes are not made in the design construction, oversight, and operation of the wet ash disposal sites throughout TVA.
- Sound engineering practice is to design such facilities with features that provide a reasonable degree of redundancy or "second line of defense" in the event that one or more of the systems become inoperable. It is important that this design philosophy be applied to all of TVA's ash disposal facilities.

This concludes my opening statement. I look forward to answering any questions that you may have. Thank you for your time.

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July 21, 2009

The Honorable Eddie Bernice Johnson, M.C.
U.S. House of Representatives
Chairwoman, Committee on Transportation and Infrastructure
Washington, DC 20515

Re: ***Testimony of William S. Almes, P.E.***
Marshall Miller & Associates, Inc. Peer Review of
AECOM's "Root Cause Analysis of TVA Kingston
Dredge Pond Failure on December 22, 2008"
Tennessee Valley Authority - Office of the Inspector General

Dear Representative Johnson:

Per your request and on behalf of **Marshall Miller & Associates, Inc. (*MM&A*),** I am pleased to provide written testimony related to the MM&A Peer Review of the "*Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008*" report prepared by **AECOM Technologies Corporation (*AECOM*).** The written testimony contained herein is derived from the content of the reports completed by MM&A on July 9 and July 12, 2009. Copies of these reports are available upon request.

1.0 Introduction and Background

Marshall Miller & Associates, Inc. (*MM&A*) is an employee-owned Engineering News-Record Magazine (*ENR*) Top 500 company that began offering geologic services to the mining industry in 1975 and for 33 years has provided a full range of related services to the mining, utility, financial, governmental, and legal industries. Today, MM&A employs nearly 200 engineers, geologists, scientists and other professionals working from regional offices in ten states.

Members of MM&A's Project Team have been intimately involved with the development of the two engineering design manuals prepared by the **Mine Safety and Health Administration (*MSHA*)**, which specifically address the procedures that should be followed for designing and operating coal refuse impoundments and embankments. The first manual was published in 1975, and an updated version is scheduled to be released in 2009. Although these manuals were written to address the design and operation of coal refuse disposal facilities, the key chapters, which include material characterization, hazard classification, planning, staging, foundation considerations, surface drainage and storm water control, instrumentation monitoring, geotechnical engineering and design, seismic hazard assessment, seismic stability and deformation, environmental considerations, and emergency action plans, are directly applicable to the disposal of fly ash and bottom ash materials.

MM&A has also been involved with forensic studies of major waste impoundments that have experienced uncontrolled releases of fine slurry, as well as slope instability within the embankment portions of both coal ash embankments and impoundments and coarse coal refuse dams.

2.0 Summary of MM&A's "Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008," dated July 9, 2009

The **Tennessee Valley Authority (*TVA*) Office of the Inspector General (*OIG*)** engaged MM&A to conduct a peer review of the Root Cause Analysis (*RCA*) prepared by AECOM relating to the ash dredge cell failure which occurred at the TVA Kingston Fossil Plant (*Kingston*) near Harriman, Tennessee, on December 22, 2008. On June 25, 2009, AECOM publicized the results of its comprehensive six-month study entitled "*Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008*." According to AECOM, the root cause of the failure was a long-evolving set of conditions, including a combination of the high water content of the wet ash, the increasing height of ash, the construction of the sloping dikes over the wet ash, and the existence of an unusual foundation layer consisting of sensitive slimes and silts.

MM&A initially visited the Kingston facility on February 4, 2009, and met with various representatives of the OIG, TVA, AECOM, **Tennessee Department of Environment and Conservation (*TDEC*)**, and **Environmental Protection Agency (*EPA*)**, among others, during the course of the engagement. Subsequently, MM&A was provided access to various documents including engineering design drawings, photographs, aerial maps and other relevant materials which were reviewed in the context of the engagement.

MM&A did not conduct a parallel investigation to AECOM's. MM&A's professional opinions are based principally on the review of various documents regarding Dredge Cell 2, a meeting with AECOM personnel at their Vernon Hills, Illinois, office location on June 2, 2009, briefings provided by AECOM during presentation and conference call meetings, and a review of the final RCA report dated June 25, 2009.

On July 9, 2009, MM&A published a report entitled "*Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008,*" in which it concluded that: (1) the scope of the RCA, as presented by AECOM, was sufficiently thorough for the RCA, and AECOM applied appropriate methodologies, investigative methods, in-situ testing techniques, and sampling practices; (2) the characteristics of the loose, wet ash indicate the wet ash as a probable root cause of equal or greater significance to the soft foundation soils; and (3) that, because the failure was not strictly associated with the "thin, weak slimes" layer and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

3.0 Summary of MM&A's "Historical TVA Documentation Review Summary, Opinions and Recommendations Related to the TVA Kingston Dredge Pond Failure on December 22, 2008" dated July 12, 2009

In addition to its July 9, 2009, peer review report, MM&A was also engaged to discuss design practices and the historical development of the disposal facility as it relates to the siting, design and construction of the containment dikes at Kingston up to the time of failure on December 22, 2008. Also discussed were overall opinions and recommendations related to the TVA Kingston dredge pond failure.

MM&A met with various representatives of the OIG, TVA, AECOM, TDEC and EPA, among others, during the course of its engagement, and was provided access to multiple documents including engineering design drawings, photographs, aerial maps, internal TVA memoranda and various reports produced by TVA's consultants, as well as other documents which were reviewed in the course of the engagement.

On July 12, 2009, MM&A published a report entitled "*Historical TVA Documentation Review Summary, Opinions and Recommendations Related to the TVA Kingston Dredge Pond Failure on December 22, 2008*" concerning appropriate design philosophy, design standards, and construction and operations procedures that are applicable to coal ash disposal facilities. MM&A's opinions were based on extensive experience with a variety of ash ponds, mine waste embankments and slurry impoundments that have been operating throughout the United States for several decades. MM&A also commented on salient aspects of the evolution of the facility.

4.0 General Background on Historical Ash Disposal Practices

AECOM documented the history of development of coal ash disposal at Kingston, including the depositional and construction history of Dredge Cell 2 and of Dike C surrounding Dredge Cell 2 (See *Section 1.2* of the AECOM's RCA report dated June 25, 2009). Several important factors are observed from this history:

- The coal ash storage facility was built over portions of the former Swan Pond Creek flood plain. Clayey sediments found below Dike C and Dredge Cell 2 are "lacustrine," a term which refers to sediments deposited in lake environments. The type of sediment deposited in lakes can vary widely and locally depends upon the size of the lake, the climate, and the nature of the surrounding soils and environment.

- Prior to the construction of the initial ash containment dike, fly ash from the plant was sluiced directly into the Watts Bar Reservoir.

- In 1958, Dike C was completed creating the Ash Pond.

- Since the passage of the Clean Water Act in 1972, many industries in the United States, including the power industry, implemented new waste handling and disposal

practices in an effort to prevent pollution of surface water and groundwater features. As a result of the operational changes, containment dikes for the ash disposal ponds were required. The upstream construction method, as depicted in **Figure 1** of MM&A's July 12, 2009, report, consists of raising the crest of the impounding dike by constructing each successive dike, or stage, above previously placed/sluiced ash, which then becomes the foundation material.

- While employing the upstream construction method during the vertical expansion of the existing dredge pond, TVA's use of this practice at the site resulted in Dredge Cell 2 having a series of ash dikes built with 3 horizontal to 1 vertical (3H:1V) slopes and 15-foot wide benches founded on 35 to 40 feet of hydraulically placed or sluiced ash, with a 200-foot setback from the original Perimeter Dike C. The ash used for dike construction was dredged from an adjacent ash collection/settling pond which was allowed to dewater over time.

- As the height of the dikes was increased, the dredge cell footprint area decreased as new lifts of material were placed. Consequently, more height was necessary to provide adequate storage for the same annual production of ash at the fossil plant. This process increased the total load and rate of loading imposed on the sluiced ash.

- Samples of the sluiced ash indicate that it has a high void ratio and does not show signs of consolidation or densification under the weight of new ash placed over older ash. As a result, the wet ash remains very loose and susceptible to liquefaction under rapid loading or rapid displacement.

- Laboratory test results also indicate that the wet ash is prone to experience static liquefaction due to its highly sensitive structure, which shows a rapid decrease in its shear strength when it changes from a drained to an undrained behavior.

5.0 Potential Failure Modes, "Triggers," and Most Probable Factors/Root Causes of Failure

In simplistic terms, the failure of Dredge Cell 2 and Dike C was the result of the hydraulically placed/sluiced ash assuming undrained behavior, resembling a liquid, and flowing into the Swan Creek flood plain and surrounding acreage. A technical review of the fly ash material identified several factors that indicate the conversion from a stable to unstable condition, which occurs rapidly as a result of the material's placement into undrained shear failure. In a technical letter report dated June 25, 2009, prepared for Mr. Ralph E. Rodgers, Assistant General Counsel for TVA, Dr. Gonzalo Castro, Ph.D., P.E., a Geotechnical Consultant from Lexington, Massachusetts, presented his conclusions regarding AECOM's analyses of the failure at Kingston. Castro succinctly explains the physical conversion from stable (drained) strength to the substantially lower (undrained) strength of the ash material[1]. The physical process involved in the liquefaction conversion is well documented in the literature for soils or

[1] Dr. Gonzalo Castro, Ph.D., P.E., Geotechnical Consultant, to Mr. Ralph E. Rodgers, TVA, June 25, 2009, Page 3.

materials with properties similar to the ash analyzed and tested by AECOM. Castro further observes that "Liquefaction caused by non-seismic triggering is referred to as static liquefaction… and [is] caused by a) slippage elsewhere in the soil [ash] mass… b) an increase in the rate of loading… and c) local relatively rapid erosion at the toe of slopes…"[2] AECOM concludes that increases in the rate of loading and localized failure at the toe of slopes or other surface/outslope areas are lesser possibilities of triggering the failure that occurred.

In the course of its analysis, AECOM identified the following probable root causes of the Kingston ash pond failure:

1. Fill geometry (upstream-constructed dike configuration on sluiced ash foundation);
2. Increased fill rates (increased loads and loading rates due to higher fill levels and shrinking footprint);
3. Soft foundation soils (weak, sensitive silt and slimes foundation layer); and
4. Loose, wet ash (hydraulically placed/sluiced ash).

AECOM discussed the thin layer of slimes beneath the dikes of Dredge Cell 2, per item 3 above, which was discovered during its subsurface investigation. Slimes do not exist beneath Dike C. Although the properties of this slime layer suggest it as a potential slippage surface based upon mathematical modeling, it is MM&A's opinion that it is not the only possible slippage surface. AECOM documented that slimes were not found in some locations, were not of consistent thickness, and had properties very close to those of the ash material itself.

It is MM&A's professional opinion that the characteristics of the loose, wet ash, such as the rounded particle shape, weakly fused and loose particle structure, sensitivity, consistently high void ratios with increasing depth (lack of consolidation behavior), along with the contractive undrained behavior and very low undrained steady-state shear strength evidenced in the laboratory tests, pose the wet ash as a probable root cause in the failure of Dredge Cell 2.

6.0 Conclusion and Observations

The following outlines MM&A's conclusions and observations based on its review of AECOM's June 25, 2009, RCA report as well as its review of various documents regarding Dredge Cell 2, a meeting with AECOM personnel at their Vernon Hills, Illinois, office on June 2, 2009, and briefings provided by AECOM during presentation and conference call meetings.

6.1 AECOM's RCA

In summary, MM&A found the following with regard to AECOM's root cause study and culminating RCA report dated June 25, 2009:

[2] Ibid, Page 4

1. The scope of the RCA, as presented by AECOM, was sufficiently thorough for the RCA, and AECOM applied appropriate methodologies, investigative methods, in-situ testing techniques, and sampling practices.

2. The laboratory geotechnical testing program was sufficiently thorough and applied appropriate and complementary suites of tests to characterize the native soils and non-native site materials (e.g., ash and slimes) in the primary areas of interest for the RCA. However, MM&A understands that AECOM was not able to recover and extrude undisturbed samples of the hydraulically placed ash for laboratory testing. This situation adds uncertainty to AECOM's characterization of the hydraulically placed ash at Kingston; thus, the role of the loose, wet ash as a root cause of the failure can not be discounted.

3. AECOM discussed the thin layer of slimes beneath the dikes of Dredge Cell 2, which was discovered during its subsurface investigation. Slimes do not exist beneath Dike C. Although the properties of this slime layer suggest it as a potential slippage surface based upon mathematical modeling, it is not the only possible slippage surface. AECOM documented (*Sections 1.3.4.2* and *1.7.11* of the RCA report dated June 25, 2009) that slimes were not found in some locations, were not of consistent thickness, and had properties very close to those of the ash material itself.

4. The characteristics of the loose, wet ash (hydraulically placed/sluiced ash) such as the rounded particle shape, weakly fused and loose particle structure, sensitivity, consistently high void ratios with increasing depth (lack of consolidation behavior), along with the contractive undrained behavior and very low undrained steady-state shear strength evidenced in the laboratory tests, pose the wet ash as a probable root cause of equal or greater significance to the soft foundation soils (weak, sensitive silt and slimes foundation layer).

5. The fundamental conclusions of AECOM's RCA with regard to the four most probable root causes or factors contributing to the Kingston ash pond failure are technically plausible and reasonably supported by the study data. MM&A concurs with AECOM that some or all of these four factors discussed contributed significantly to the failure.

6. MM&A concludes that, because the failure was not strictly associated with the "thin, weak slimes" layer and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

7. MM&A notes that the stated objectives of the AECOM RCA do not encompass the task of identifying necessary changes in design philosophy, design standards, construction documentation, inspection and instrumentation to prevent another Kingston-type failure. Consequently, the root cause study and culminating report by AECOM defines the problem but does not provide clear direction to TVA in

the form of technical guidance for evaluating, designing, and constructing reliable containments for "wet" ash disposal now or in the future.

8. MM&A believes that the AECOM RCA focused disproportionately on the significance of the thin, discontinuous, soft foundation layer (sensitive silt and slimes) as one of the most probable factors/root causes. The significance of the "Fill Geometry" factor/root cause should be equally emphasized. In the Kingston case, the specific complexities and uncertainties associated with the ash dikes/embankments constructed over the hydraulically placed or sluiced ash deposits (i.e., upstream-constructed containment) is an important component of the "Fill Geometry" factor and, in MM&A's professional opinion, is of equal or greater significance relative to the "Soft Foundation Soils" factor.
9. Other factors evaluated by AECOM as probable root causes should be strongly considered by TVA and the power generation industry as a whole in evaluating the condition and structural integrity of wet ash disposal facilities. Each one of these factors is critical and should be closely examined at all of the existing TVA ash handling and disposal facilities. These concerns and findings could have a significant effect on the requirements and standards of care for facilities throughout the industry.

6.2 General

During its historical record review, meetings and observations, MM&A determined the following:

1. As early as 1985, intrinsic problems related to the stability of Dike C were mentioned, specifically in a TVA memorandum (see **Exhibit 1** of MM&A's July 12, 2009, report) which indicates that the calculated factor of safety was less than the minimum acceptable value of 1.5 and close monitoring was recommended to detect any potential signs of failure–in lieu of changing TVA policies and procedures that would require that the ash pond be designed to the higher "dam safety" standard. No specific action by TVA appears to have been taken as per the reviewed documents to improve the stability of the earthen Dike C embankment.
2. The construction of successive upstream stages to elevation 820 (approximate crest elevation of Dredge Cell No. 2 at the time of failure) above the original containment dike may have contributed to an additional decrease in the factor of safety of the containment dike system. In essence, at the time of failure on December 22, 2008, this increase in constructed height equated to an approximate 70-foot increase in the height of the ash pond above the crest elevation of the original Perimeter Dike C.
3. In MM&A's opinion, if TVA had included its ash ponds in the Dam Safety Program as discussed in December 1988 when TVA decided against this policy,

the probability of identifying some or all of the conditions that led to the Kingston failure would have increased significantly.

4. The design of the Kingston coal ash dredge cells should have included a thorough engineering evaluation of all potential failure modes.

5. It is considered sound engineering practice to design such facilities with features that provide a reasonable degree of redundancy or "second line of defense" in the event that one or more of the systems become inoperable. To some extent, establishing higher factors of safety provide this protection. However, other considerations are appropriate such as specifying a sufficient number of internal drains in the event one or more become clogged or compromised in some fashion. The same applies to specifying the degree of compaction of the dike materials since weather conditions, the level of experience of the equipment operators and other variables can affect the final condition and ultimate behavior of the structure. In MM&A's opinion, it is important that this design philosophy be applied to all of TVA's ash disposal facilities.

6. The recommendations made by **Geosyntec Consultants, Inc. (*Geosyntec*)** following its peer review of the 2004 TVA document entitled "Operations Manual–Dredge Cell Lateral Expansion" were appropriate, and the failure of TVA to respond to such warnings and affect necessary revisions to the design shows that conservative engineering design principles were not being followed within TVA. Furthermore, had corrective measures been completed in a timely manner, it is possible that TVA could have potentially prevented the occurrence of the failure.

7. With regard to the TVA reaction to the 2003 ash slope failure along Swan Pond Road, buttress construction was a reasonable immediate response. However, use of riprap material alone without proper filter materials between the existing ash dikes and riprap buttress, whether 50 feet or 250 feet wide, was not a technically acceptable longer term solution. Rather than adopting a "wait and see" approach with the 50-foot wide buttress, the problems and potential longer term solutions warranted prompt evaluation by a qualified geotechnical/dam engineer. If the ash ponds had been included in the Dam Safety Program, this closer evaluation and a more sound "engineered" solution probably would have occurred.

8. It is evident from findings and recommendations in the Geosyntec report that, in addition to consideration for liquefaction, modifications to the expansion design should have been made to require compliance with a more stringent design configuration. Upon completion of the proposed Phase 2/3 expansion, which had not occurred at the time of the failure, more height and weight would have been added to what is now the failed ash pond. TVA's concurrence with the recommendations would have resulted in additional extensive analyses and modeling.

9. It is not prudent to presume that if the slimes layer observed in the failed section at Kingston does not exist at other plant sites, there is adequate stability of these structures. On the contrary, the information developed from the extensive studies

conducted by both **Stantec Inc.** and AECOM indicates that there is a reasonable risk of other dike failures if changes are not made in the design construction, oversight, and operation of the wet ash disposal sites throughout TVA.

7.0 Closing

In preparing this testimony, the professional services of MM&A have been utilized, findings obtained, and conclusions made in accordance with generally accepted engineering principles and practices. MM&A reserves the right to amend and supplement this testimony based on new or additional information that might be obtained or become known. If OIG, TVA, TVA's consultants, or others discover additional information pertinent to the Kingston ash pond failure or related studies, MM&A requests the opportunity to review the information for significance relative to MM&A's findings and conclusions as presented herein.

Should you have additional questions, please call me at (919) 786-1414. Thank you very much.

Sincerely,

MARSHALL MILLER & ASSOCIATES, INC.

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Tom Kilgore, President and Chief Executive Officer

Tennessee Valley Authority

Before the

U.S. House Committee on Transportation and Infrastructure

Subcommittee on Water Resources & Environment

July 28, 2009

The Tennessee Valley Authority's Kingston Ash Slide:
Evaluation of Potential Causes and Updates on Cleanup Efforts

Introduction

Chairwoman Johnson, Ranking Member Boozman, and members of the Committee. I appreciate this opportunity to provide an update to you on the progress we are making following the coal ash spill at the Tennessee Valley Authority's (TVA) Kingston Fossil Plant. We are working diligently to restore conditions in the Kingston community, and we have marked some important milestones in that recovery. We have also taken actions toward fulfilling our commitment to determine the root cause of the ash spill and to ensure that no similar incident occurs ever again at a TVA facility. In addition, we are incorporating the lessons learned from the Kingston spill into our management initiatives in order to improve TVA's performance and reputation. The recovery and remediation of the Kingston site is a long-term effort with implications for our nation's energy future.

Those of us at TVA appreciate the committee's interest in the ash spill at Kingston, and we particularly appreciate Chairwoman Johnson's visit to the site in early June to see the recovery work and meet personally with members of the Roane County community.

As you know, the incident occurred at Kingston Fossil Plant in Roane County, Tennessee, on December 22, 2008. On behalf of TVA, we deeply regret the failure of the ash storage facility dike, the damage to adjacent private property, and the impact to the environment. We are grateful that no one was injured. Since the time of the event, we have taken full responsibility for the clean up and recovery of the ash spill. We are doing the restoration work with the oversight of the U.S. Environmental Protection Agency (EPA), as well as the Tennessee Department of Environment & Conservation, and we are continuing to work closely with the Kingston community. The TVA Board of Directors is actively engaged in ensuring that TVA manages this work effectively and that we do so in a responsible and transparent manner.

TVA continues to be committed to protecting the health and safety of the public and site workers. Sadly, there was a fatality at the Kingston site on Monday, July 20. A contractor was unloading pipe for the dredging operation when the accident occurred. The circumstances of the accident are being fully investigated. All of us at TVA extend

our deepest condolences and sympathy to the family and friends of Mr. Larry LaCroix of Burlington, Iowa, and our thoughts and prayers are with them.

Today, I want to cover two things specifically: the cause and the recovery. This event was a wake-up call for TVA, and a failure in our commitment to TVA's mission to make the region a better place to live, work and raise a family. We are working hard to rebuild the public's trust. In the months since Kingston, we have taken aggressive action – from cleaning up the site, to instituting a comprehensive program to assess issues at our other sites. Although we have made good progress, our work is far from done, and I also want to discuss next steps with you as TVA undertakes a critical review of our overall organizational effectiveness.

First, allow me to address the more complicated item, and that is the cause of the Kingston failure.

Root Cause Analysis

Following the spill, we committed ourselves to determine what caused the failure and to prevent a similar event at any other TVA facility.

This work consists of a two-pronged approach, both technical and organizational in nature. On the technical side, our first priority was to engage a top-flight engineering firm to conduct a root-cause analysis to determine what happened on the night of the event. We also hired another highly regarded engineering firm to undertake a review of all of TVA's ash ponds at our 11 fossil plants and the now-closed Watts Bar plant.

Second, on the organizational side, the TVA Board of Directors commissioned the law firm of McKenna Long & Aldridge (MLA) to look at any management, controls and standards issues that may have contributed to the event and to make recommendations on culture and organizational effectiveness.

The root-cause analysis was conducted independently by AECOM Technology Corporation, a leading geotechnical engineering firm. I specifically asked TVA's General Counsel to select the contractor and administer the contract in order to provide as much independence as possible. I felt it was important that the Chief Operating Officer organization not run the analysis in order to maintain its focus on spill containment, restoration at Kingston, and a review of our other sites. In addition, it was important that the firm selected not have any previous involvement with TVA or its ash ponds.

The AECOM team is internationally respected in the fields of geotechnical engineering and forensic analysis; it brought to this project substantial experience in design, construction quality management, and forensic failure analyses of dikes,

containment ponds, landfills, and dams. In its forensic investigation of the Kingston failure, the AECOM engineering team took hundreds of soil borings and numerous core samples and performed extensive laboratory testing on the samples. The team also performed exploratory excavations; installed instrumentation; studied maps, photographs and surveys; analyzed relics from the coal ash release; reviewed design records and drawings; and interviewed TVA engineers and site operations personnel. The team then subjected its findings to peer review by a geotechnical consultant.

The study concludes that the ash spill was caused by an unusual combination of long-evolving conditions – the existence of an unusual bottom layer of ash and silt, the high water content of the wet ash, the increasing height of ash, and the construction of the sloping dikes over the wet ash. The analysis documents conditions at the Kingston site that date back to the plant's construction in the 1950s.

Throughout its work, AECOM shared information with the Tennessee Department of Environment & Conservation advisory work group which includes the independent consulting engineers retained by the Tennessee Department of Environment & Conservation, TVA's Office of Inspector General, and an EPA Representative. This group met several times to conduct workshops and review data as it was being collected and processed, and we encouraged all participants to raise any concerns about AECOM's analysis as that work proceeded.

Since the report was released, other points of view have been voiced. We remain open to new information about Kingston and will give the differing findings full consideration. We have carefully studied AECOM's report, and we believe it provides a thorough, well-documented, and appropriately reviewed assessment of the physical conditions that resulted in the failure of the ash dredge cell at Kingston and the mechanisms of that failure.

Actions and Accountability

TVA is carefully considering the findings in the AECOM report as we evaluate next steps for closing the failed dredge cell at Kingston and take actions to improve storage facilities at other TVA fossil plants. In addition to the root cause analysis, we moved quickly to establish a more comprehensive evaluation, inspection, and maintenance program to confirm that all of TVA's ash and gypsum storage facilities are – and remain – structurally sound.

That program encompasses three important aspects -- a review to determine the best storage method for each plant site, an organizational change to heighten our management focus on storage facilities, and the work begun in January by the engineering firm Stantec to assess all our facilities.

Overall, as we evaluate each of our coal-fired plant sites, we are determining the most effective and appropriate storage methods for each site. This requires us to evaluate a number of factors, from plant operations to the topography of each site. We are developing a plan to eliminate wet storage of fly ash at all of our facilities. (Currently, five of TVA's 10 other fossil plants use wet fly ash storage cells. The other five plants use a dry ash storage method).

With the organizational change, responsibility is consolidated for all storage ponds in our system in a specific organization that reports directly to our Chief Operating Officer. This new arrangement ensures that we have heightened management accountability and institutional focus on the engineering, operation, and maintenance of the storage facilities.

Stantec was commissioned in January to inspect, test, and make recommendations on ash and gypsum disposal facilities at all our fossil plants. Five teams of Stantec employees have visited all the TVA fossil plants, and initial results suggest no evidence of imminent failure at any TVA ash storage facility.

Stantec began its work with site walk-downs, reviews of available documentation, and detailed site reconnaissance. Stantec has made its initial recommendations, and we have been working aggressively to implement those maintenance and engineering changes over the past six months.

Stantec has completed 428 subsurface borings which represent 23,565 feet of total footage bored. Nine boring rigs are currently mobilized. Over 3,500 laboratory tests (for moisture content, composition, unit weight, compression and permeability) have been completed and 66 advanced tests (52 cone penetrometer tests and 14 shear vane tests to be used for stability modeling). The installation of 44 slope inclinometers has been completed to detect any slope movement along with 210 piezometers to measure water levels.

To date, 82,000 tons of rock have been applied to increase road and slope stability. Over 10,000 cubic yards of trees and vegetation have been removed to allow for better visual inspections of dike crest and slope conditions.

Subsequent work includes more engineering studies and analyses to further determine the structural integrity of each facility, complete geotechnical explorations, hydrologic/hydraulic analyses, and mitigation and conceptual designs. Stantec's Phase 1 reports have been released to EPA; the states of Tennessee, Alabama and Kentucky; and the public.

The arrangement with Stantec ultimately will provide us with better programmatic support for facility maintenance, improved annual inspections, and the application of more rigorous safety program standards to ash and gypsum facilities. The Tennessee Department of Environment & Conservation also has independent contractors looking at our sites in Tennessee, and we welcome any recommendations they may have.

In addition, in the interest of taking a conservative, self-critical approach, we have reassessed the potential hazard classifications of the wet storage coal combustion impoundments at each of our 11 fossil plants and the now-closed Watts Bar plant. Using criteria based on the National Dam Safety Guidelines, we evaluated the potential consequences of a worst-case failure of the wet storage impoundments. Although we have received no indications that any of our impoundments are in danger of failing, we have preliminarily reclassified impoundments at four of our 12 plant sites as having "High" hazard potential. We are prioritizing our efforts at these sites to ensure that the storage facilities remain safe, and we are continuing to focus on other impoundments, as well. We have communicated about this with EPA, the states where our coal plants are located, and the public.

Systems, Controls, Standards and Culture

One additional area we are addressing among TVA management and employees is the overall culture in our organization. Every day, around the clock, TVA employees are on the job, providing reliable, affordable electricity, managing the river system, and encouraging economic development in the region. TVA employees have a long-standing tradition of service to the Valley region, and I am proud to be one of them. Their diligent work on the Kingston recovery is an outstanding example of their dedication and spirit.

However, it is apparent that opportunities were missed for TVA to make changes to its practices that might have prevented the Kingston event. Decisions not to adopt dam safety guidelines for TVA ash ponds are an example of such opportunities. These missed opportunities are indicative of a larger cultural problem at TVA, in how all of us at

TVA think and act on risks; how we process and share information; and how we build a stronger sense of accountability in all we do. Culture has also been highlighted as a concern in the report conducted by McKenna Long & Aldridge (MLA) for TVA's Board of Directors, and I know is of concern to TVA's Inspector General as well.

MLA was specifically tasked by the TVA Board to look at the Kingston spill as a basis for improvement in TVA's management, systems and controls, yet another important step to prevent a similar event from ever occurring again. I have told TVA employees that the MLA report is tough, but good medicine and we take it because we know we can get better. While the descriptions of our shortcomings are not easy to hear, MLA findings and conclusions are another important milestone.

MLA addressed the fundamental question of system and culture failures around the Kingston spill and the management of TVA's other ponds. In sum, their review found that the necessary systems, controls and culture were not in place to effectively manage this important part of TVA's operations. Among the deficiencies noted are:

- lack of clarity and accountability for ultimate responsibility,
- lack of standardization, training and metrics,
- siloed responsibilities and poor communication,
- lack of checks and balances,
- lack of prevention priority and resources, and
- reactive instead of proactive approaches in lessons learned and safety.

Over time, and throughout TVA's 76 year history, an organization structure has evolved which was siloed with accountabilities dispersed throughout various units. With regard to ash management and storage in particular, these silos led to a lack of internal communication, sharing and follow-up on important issues. As a consequence, opportunities to anticipate or avoid problems may have been lost. With little sharing of information internally and no clear accountability, a culture was created in which the management, storage and disposal of coal ash and other combustion products were not seen as significant as other aspects of TVA's operations. Decisions made were not in keeping with a conservative approach to engineering and operations.

The Kingston incident has now focused a great deal of attention on engineering and operations at TVA. It also has focused our attention on opportunities to improve the rigor and discipline with which we approach every aspect of our work. Given the nature of our operations and the potential impacts to people and the environment, everything

we do requires vigilant attention to safety, procedures and regulations, as well as to regular inspecting, monitoring, and documenting of our work.

The MLA report points out that TVA has made 'significant remedial progress in relation to preventing any future pond spills,' and we appreciate their recognition of our work over the last few months. There is a cautionary note, however, from MLA that we take seriously. Legacy culture challenges exist at TVA, and our task going forward must be not simply to continue progress but to sustain that progress across the organization and over time.

The TVA culture must be one in which rigorous, disciplined adherence to standards is a way of life, and we are working to renew that aspect of TVA's culture. This is a problem we must fix.

As a result of these reports—AECOM, Stantec and MLA, along with the Inspector General's reports—we have several lessons learned about the challenges facing us, and I have summarized some of them, as follows:

- Storage facilities and structures should not be built in areas where stability cannot be assured and verified.
- Aggressive and rigorous inspections and structural analysis of all coal combustion product storage have been initiated and will be kept current.
- Management will visibly demonstrate and emphasize the need for self-assessments to promote objective and fact-based reporting, inspections and auditing.
- Safety related risks must be given the highest priority to identify, minimize and eliminate risks.
- Engineering design philosophy, design and construction of ash management facilities must be standardized.
- The handling, storage and disposal operations for coal combustion products must be standardized.

All of these lessons learned tie into a broader observation. It is apparent that lack of clarity within the organization led to poor internal communications, unclear accountability, a lack of follow-through on issues and poor procedural compliance.

As a consequence, it is imperative that TVA must have:

- Clear accountabilities,
- Strong governance,
- Robust self assessment

- Independent reviews for quality and compliance, and
- a culture of personal responsibility and problem solving.

At the Board's direction, we will initiate an agency-wide organizational effectiveness plan, focused on change management, performance and compliance. This is a high priority for us in the coming months as we rebuild and refocus our internal culture committed to systems, controls, standards, accountability, and an overall effort to address legacy culture challenges.

Progress Report: Recovery Operations

Now, to the second aspect of what I would like to cover today and that is our progress at Kingston, including recovery operations, environmental conditions and community outreach.

Every day since December 22, 2008, TVA crews and contractors have been on the job, working to correct conditions. While complete recovery is a long-term effort, I am glad to report that we have now worked with Roane County and local utilities to rebuild all roads and water lines, and all roads affected by the spill are now open to the public. The rail line initially covered by the spill was cleared and opened for use in January, and two new rail spurs have been built on the site for use in transporting ash from the spill to offsite disposal facilities. When Chairwoman Johnson visited the site, she was able to see some of the progress for herself, and I have a few slides to share with everyone here today:

- Church slough before and after ash recovery
- Emory River channel before and today after Dike 2 construction

In the recovery work, TVA has entered into an administrative order and agreement on consent with EPA to provide for EPA's oversight of the clean-up under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). We believe that applying the federal CERCLA requirements, with EPA oversight, to the Kingston site assures the public that TVA is carrying out all the response actions necessary to protect public health and the environment. The CERCLA process also provides a process for meaningful public input which we believe will be helpful with regard to response actions at this site. This arrangement brings to the cleanup work EPA's specialized expertise to better ensure that the work will be done expeditiously and in keeping with all federal and state environmental requirements.

The administrative order and agreement on consent with EPA continues the work among EPA, the Tennessee Department of Environment & Conservation, and TVA that began back in December; and we appreciate the sound working relationship in place at the site. TVA submits all of our work plans and schedules to EPA for review and approval, and EPA helps provide a meaningful approach to community involvement in the cleanup work. Our common goal is for the cleanup to meet the nation's highest standards for effectiveness, transparency, and public involvement.

As you know, we met a key milestone in mid-March when we began dredging operations to remove ash from the navigation channel of the Emory River. We are doing this work under a dredging plan approved by EPA and the Tennessee Department of Environment & Conservation to remove ash as safely and efficiently as possible in a manner that protects the public health and the environment. Water quality monitoring equipment has been placed in the river to continuously monitor water clarity and quality upstream and downstream of the dredging operation.

The work currently under way is the first phase of our dredging operations, which will partially clear the river channel to restore flow without disturbing legacy, natural river sediments. Future work to fully restore the river channel to its original depth will occur during the second phase of dredging.

At this time, we are using barges with hydraulic dredges along with piping to move the dredged material back onto the plant site. A barge also will be used to remove any debris that is found as dredging progresses, such as large rocks, trees, limbs, and other items that may be submerged in the river.

We are taking steps to minimize inconveniences to residents of the area, including installing special noise reduction equipment on the diesel engines, pumps, and compressors and devices to reduce the glare of lighting at night.

To date, we have dredged or excavated almost half a million cubic yards of ash at a peak rate of about 12,500 cubic yards a day. By mid-August, we will be operating two dredges at the site, with an expected capacity to dredge as much as 20,000 cubic yards of ash per day. We estimate 3 million cubic yards of ash recovered from the Emory River will be removed over the next 12 months.

The second major milestone we recently met was making the first rail shipments of dredged ash from the site to a permanent disposal site. This important step was approved by EPA, which requires any storage facility we use for the coal ash to meet the most stringent protective disposal standards for municipal solid waste landfills.

TVA received and rigorously evaluated about 25 proposals before selecting the Arrowhead Landfill in Perry County, Alabama, as the site. The Arrowhead Landfill is a state-of-the-art, fully permitted, state-regulated, Subtitle D municipal solid waste landfill and has been operating since 2007. It is in Uniontown, Perry County, Alabama, and is managed by Phillips & Jordan. The Arrowhead Landfill meets and exceeds EPA's requirements, as adopted by the Alabama Department of Environmental Management. TVA's evaluation of proposals from companies interested in receiving the ash shipments included a comprehensive examination of numerous loading, transportation, and disposal options and approaches.

During transport, the moisture content of the ash, along with a number of handling and transportation safeguards, helps ensure that ash does not become air borne during loading and shipment. At the landfill site, the fly ash is stored separately from the other material there. The composite liner system at the landfill consists of 2 feet of compacted clay, overlain by a geo-membrane liner, which is overlain by a 2-foot thick drainage layer.

Before the shipments to Perry County began, the landfill had five full-time employees. Its operators now expect to hire 40 to 50 new local employees to manage the fly ash disposal at full production. Tipping fees for the disposal in the Arrowhead Landfill will generate revenue for Perry County.

To ensure a good working relationship with the Perry County community, senior members of TVA's staff met with community leaders and elected city and county officials and visited businesses and schools in the community. TVA also hosted a meeting of Perry County officials at the Kingston Fossil Plant to provide information on the production and characteristics of coal-combustion by-products, particularly fly ash. We are sensitive to the concerns raised by community members and are continuing to work locally to address them.

Progress Report: Environmental Conditions

Our highest priority continues to be the health and safety of the public and employees. We are continuing the ongoing and comprehensive monitoring of air and water samples in and around the site, and environmental monitoring will continue long-term, after site cleanup is complete.

Results of extensive water-testing by multiple agencies show that public and private water supplies continue to meet drinking water standards. Results from more

than 71,000 air samples taken to date confirm that levels of particulate matter and metals remain below national and state standards, and we are continuing measures to suppress dust and prevent ash from becoming airborne. While samples of the ash itself show that most metals in the ash are similar to those found in natural soils in the area, we continue to recommend that the public avoid contact with ash. Additionally, we have instituted more stringent practices to ensure that ash does not leave the site on trucks and other equipment or apparel, such as workers' boots.

In addition to the many certified lab results now on the record, some other environmental data has been discussed by a variety of groups since the spill, and the data is described as differing from the findings of the independent labs used by TVA and the Tennessee Department of Environment & Conservation. TVA takes these reports seriously, and we are interested in any information with the potential to affect public health and the environment. When we hear of these reports, we make every effort to review the findings to further ensure that our monitoring procedures are thorough and accurate. An interagency working group of state, federal, and industry experts assists in evaluating the data from monitoring and identifying actions necessary to ensure the protection of the public health and the environment.

At the same time, TVA recognizes that local residents have health questions and concerns. The health and safety of the people living near the Kingston site are of primary concern to the TVA, and we have contracted with Oak Ridge Associated Universities (ORAU) to provide independent health screening for residents living near the ash release.

ORAU is a university consortium with access to the expertise of 100 major research institutions. Working in conjunction with physicians from Vanderbilt University, ORAU is developing a medical evaluation protocol for local residents. ORAU will implement a process that provides access to medical and toxicology experts knowledgeable in the health effects related to contaminants. ORAU also will work with local physicians to provide them with information and support to address their patients' concerns. ORAU is solely responsible for developing the health assessment protocols and subsequent medical evaluations. TVA will not have access to any confidential medical records or names of individuals who have health evaluations; TVA will receive summary reports on progress, including the number of participants and trends. Information about the program is being provided to local residents directly from ORAU.

TVA is also working with ORAU to provide $3 million over three years to support peer-reviewed research that will help everyone better understand the properties of coal combustion by-products and develop technology for using them. This includes identifying alternative ways to contain, handle, and process by-products, characterizing their properties so that more by-products can be reused, and better understanding the effects of coal fly ash releases into the environment. While TVA is funding the effort, ORAU is managing the independent proposal review and grant process that will benefit the public and industry. Eligibility for the funding is open to colleges and universities, research institutions, private companies and qualified individual researchers.

Progress Report: Community Outreach

As I mentioned, we are grateful that no one was injured when the spill took place. When the incident happened, we immediately began reaching out to local residents, and the people most affected by the spill have continued to be our priority. We are working closely with local residents and public officials and the Roane County Long-term Recovery Committee. We hosted our first open house in the area in January with representatives from key state and federal agencies. We have also hosted two other public meetings and participated in numerous homeowner and community meetings, events, and presentations.

The community outreach center in Kingston has worked with almost 750 families to address their questions, concerns and property damage claims. The center also provides information about the Kingston recovery. We are working hard to be responsive and responsible as we address property owners' claims, and we appreciate the patience of the property owners as we have worked through this process. As I mentioned, the released ash covered about 300 acres, of which eight acres were privately owned lands, not owned or managed by TVA. Within the first month, TVA began purchasing affected properties, using appraisals by state-certified residential and general appraisers. Offers were made based on the higher of two independent appraisals. The appraisals are based on property values as of December 20, 2008, before the spill. TVA has purchased more than 125 pieces of property, a total of about 440 acres. We have also assured local officials that Roane County property tax revenues will not be negatively affected by the purchase of these properties.

As we make progress toward setting things right in the Kingston community, however, some area residents, and even some people well outside Roane County, have

determined that legal action is how they should deal with TVA and the Kingston ash spill. In that vein, TVA must defend itself against the lawsuits that have been filed by numerous law firms seeking millions of dollars for multiple plaintiffs, including some people who live dozens of miles from the site.

At this point, TVA has a two-fold responsibility. First, we must continue to clean up the spill, recover the ash both from property and from the Emory River, and ultimately restore the area. We are working hard and making significant progress on that front. Second, we also have a responsibility to be good financial stewards for the 9 million ratepayers of the Tennessee Valley. TVA must defend itself against these multiple lawsuits. This is an important balance to maintain.

Under the difficult circumstances resulting from this incident, we have been gratified that our employees have had some bright spots in their work. Some members of the Kingston community have taken the time to write and tell us they know the positive difference TVA makes in the region and that they know we will fix this. Some residents have told us they appreciate the courtesy and attention they have received at the community outreach center and that employees there have often gone the "extra mile" to address their concerns. We appreciate these expressions of confidence, and please be assured that we will continue to live up to them.

Conclusion

Since the day the Kingston spill occurred, we have been in close contact with local, state, and federal officials; residents of the Kingston community; and members of the public in the immediate area and elsewhere. We appreciate the oversight of this committee as we recover the Kingston site and take action to ensure that such an incident does not occur again.

We take seriously the lessons learned from Kingston and are incorporating them into our management initiatives to improve TVA's performance and reputation. Others in the electric utility industry share our interest and yours in understanding how and why this occurred and what additional measures are needed to avoid any similar occurrence. This is a costly learning experience for us, and it is a learning experience for the entire industry, as well. As we work through this, new questions, concerns, and issues continue to emerge. We are anticipating those to the best of our ability and addressing them responsibly as they develop. We are also calling upon the best industry resources to provide their engineering and environmental expertise.

Long-term, we are also considering the role that coal plays in our power generating portfolio. The Kingston clean-up itself is costly, and moving from wet storage to dry storage of coal combustion by-products across the fossil fleet will be expensive, as well. If the conversion to dry storage is not economically feasible at some sites, we will have to consider retiring some facilities.

We have a goal to increase the amount of carbon-free generation we use, and we have begun an update of our integrated resource plan that looks at all energy resource options over the next two decades. The move to more carbon-free resources to meet current and future power needs will require TVA to make significant capital investments in new generation.

TVA remains committed to continuous improvement, a culture of accountability, accuracy of information, and responsiveness to those who provide oversight and guidance to TVA. We are also committed to being a national leader in technological innovation, low cost power, environmental stewardship and economic development, remaining loyal to TVA's historic mission.

Thank you for the opportunity to provide this report on the progress we are making in our recovery work, and I look forward to your questions.

Statement of Richard W. Moore

Inspector General, Tennessee Valley Authority

before the

Subcommittee on Water Resources and Environment

of the

Committee on Transportation and Infrastructure

United States House of Representatives

Madam Chairwoman Johnson, Ranking Member Boozman, and members of the Subcommittee, I am the TVA Inspector General having been appointed to this position by the President in May of 2003. Prior to becoming the first Inspector General appointed by the President at TVA, I was a federal prosecutor for approximately 18 years in the Southern District of Alabama. It is a pleasure to be able to testify here today about the Office of the Inspector General's review of the coal ash spill at TVA's Kingston fossil fuel plant in December of 2008. I believe that you have before you a copy of our report which is being made public today.

The Kingston Spill has brought intense scrutiny upon TVA and with it a call for more oversight of TVA. The conditions at TVA that led to the disaster of December 22, 2008, have existed for decades, and it is unfortunate that it has taken this kind of incident to prompt changes at TVA. But as the late Senator Everett Dirksen famously said, (paraphrasing) "Sometimes I don't see the light until I feel the heat." TVA is certainly feeling the heat, and I have reason to believe that they are seeing the light."

I am here today to report on three matters. First, I will outline briefly the TVA management failures that contributed to the Kingston Spill. Secondly, I am here to give you our assessment of TVA's progress on addressing those management failures. Finally, I am here to give you specific recommendations for TVA to make sure that a disaster like the Kingston Spill never happens again at TVA.

The TVA culture at fossil plants relegated ash to the status of garbage at a landfill rather than treating it as a potential hazard to the public and the environment. We believe this culture resulted in management failures which contributed to the Kingston Spill. Our report points out a number of issues that I would summarize into three categories:

1. **Warnings and red flags** raised by outside consultants and internal staff that were not addressed;

2. **An inadequate system of management controls** as evidenced by fragmented organizational structures, a lack of policies and procedures, and inadequate training for dike inspectors; and

3. **Poor management practices** that included a lack of maintenance on dikes and overall poor communication between organizations.

Our report provides a more detailed discussion of each of these items.

Our assessment of TVA's actions to address these management problems include:

1. **TVA's prompt hiring of Stantec**, an independent well-qualified engineering firm, to evaluate the stability of the ash ponds and to also address TVA's lack of policies and procedures, poor training, and poor engineering practices, was appropriate. The OIG will do a peer review of Stantec's work and report back to Congress.

2. **Making organizational changes** to place the management of coal combustion by-products under one organization separate from the fossil operations and clearly defining their roles and responsibilities (i.e., enhancing accountability, transparency, and communication), was appropriate. The OIG will monitor TVA's progress in this area and issue further appropriate reports.

3. **TVA has begun to implement corporate initiatives to promote cultural changes** and to improve the Enterprise Risk Management process. TVA committed to make this happen, and the OIG will carefully monitor TVA's efforts.

Finally, in addition to the recommendations in our report, the Office of the Inspector General recommends that Congress hold regular oversight hearings to determine whether:

1. TVA's coal ash facilities have either been closed properly or modified to an appropriate safety level;

2. TVA's culture has been changed to become more transparent and accountable; and

3. TVA has fulfilled its responsibilities to the citizens of Roane County to clean up their community and to make them whole.

Madam Chairwoman, you have said that, "The Kingston spill was caused by regulatory neglect, a lack of government oversight, and 'irresponsible coal ash practices.'" Our OIG report that we make public today supports your statement. TVA management knew, for example, that: (1) Consultants hired by TVA had urged them to perform a much needed analysis and to take specific corrective actions; (2) TVA failed to follow the engineers' recommendations and failed to perform the analysis or take the corrective action; (3) TVA had a history of poor maintenance of its ash ponds and had experienced seeps or breeches in the past; and (4) there were no policies or procedures at TVA for the management of coal ash. Documents supporting this have been made public by TVA and these facts are widely-known.

The TVA Board appears to clearly understand the gravity of the situation and has recently taken bold steps to address the problems that we have identified in our report. Also, although TVA management was slow to publicly discuss management failures as we point out in our report, I am pleased to say that they have made great strides in starting a long process to not only rebuild the ash management program but to attempt to rebuild the trust and respect of Congress, the American people, and TVA's many stakeholders. This will not happen without continued oversight by this Subcommittee and other oversight authorities including that of the Office of the Inspector General. We are committed to devoting resources to monitor TVA's new commitment to transparency and accountability, and we welcome your support in that endeavor.

I look forward to answering any questions that you may have.

TESTIMONY OF MATHY STANISLAUS
ASSISTANT ADMINISTRATOR
OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
SUBCOMMITTEE ON WATER RESOURCES AND THE ENVIRONMENT
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
U.S. HOUSE OF REPRESENTATIVES

July 28, 2009

Madam Chairwoman and members of the Subcommittee, thank you for the opportunity to provide testimony on the U.S. Environmental Protection Agency's (EPA's) role in the response and clean up of the release of coal ash from the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) in Harriman, Roane County, Tennessee. My testimony will provide a brief background on the incident and immediate EPA actions, current and planned actions to ensure that the ash removal and disposal is conducted in a manner that protects public health and the environment, and an update on the Agency's assessment efforts regarding the structural integrity of coal ash impoundments.

The Coal Ash Release and Response Actions

On Monday, December 22, 2008, at 1:00 a.m., a containment dike enclosing a portion of a Class II landfill impoundment at KIF failed, releasing an estimated 5.4 million cubic yards (CYs) of coal ash to the Emory and Clinch Rivers and surrounding areas. Ultimately, the ash flow extended northward approximately 3,200 feet beyond the limits of the ash pond over the Swan Pond Creek flood plain and into the Emory River, a part of the Wattts Bar Reservoir. The released ash extended over approximately 300 acres of land outside the impoundment and generated a surge of water and ash that destroyed three homes, disrupted electrical power,

ruptured a natural gas line in a neighborhood located adjacent to KIF, covered railway tracks and roadways, and necessitated the evacuation of a nearby neighborhood. An estimated three million CY of the coal ash entered the Emory River and adjacent tributaries.

Shortly after learning of the release, EPA deployed an On-Scene Coordinator (OSC) to the site of the coal ash release. EPA joined TVA, the Tennessee Department of Environment and Conservation (TDEC), and other state and local agencies in a coordinated response (i.e., Unified Command in the National Incident Management System). EPA served as the lead federal agency throughout the emergency phase of the response and provided oversight and technical advice to TVA. Lead federal agency designation transitioned to TVA as the emergency phase moved to the recovery phase of the response action. Subsequently, on May 11, 2009, EPA entered into an Administrative Order and Agreement on Consent (AOC) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), pursuant to which TVA will perform the response action with EPA oversight

Environmental Monitoring and Sampling

Since the breach, EPA (staff and contractors), TDEC, and TVA have been involved in extensive sampling and monitoring of the air, ash, surface water, and drinking water to evaluate public health and environmental threats. Results are posted at www.epakingstontva.gov and also on the TDEC and TVA websites.

As noted in EPA's previous testimony before the Subcommittee, sampling results for coal ash contaminated residential soil showed arsenic, cobalt, iron, and thallium levels above the

residential Superfund soil screening values, as well as average arsenic levels in the coal ash and coal ash contaminated residential soil above EPA's Residential Removal Action Levels (RAL). RALs are used to trigger time-critical removal actions while soil screening values are used as a point of departure for EPA to take any action to investigate and/or remediate a release. TVA has relocated residents and purchased properties that were either impacted by removal processes or that had ash on them.

Coal ash sampling results also indicate that it contains small amounts of naturally occurring radioactive material, notably the element radium. However, the concentrations of radioactive materials within the ash are below the Superfund risk range and below state and federal Applicable or Relevant and Appropriate Requirements (ARARs). These levels do not require management of the ash as a low level radioactive waste. A summary of other sampling results is below:

- sampling at multiple locations along the Clinch and Emory Rivers detected heavy metals, but concentrations were below applicable limits;
- sampling of untreated river water showed some elevated metals just after the release and again after a January storm event, including arsenic, cadmium, chromium, and lead. Subsequent sampling showed metals concentrations below drinking water limits;
- sampling of municipal water intakes at the Kingston, Cumberland, and Rockwood water treatment plants (WTPs) did not exceed any Maximum Contaminant Levels (MCLs) for drinking water;

- sampling of private residential wells near the site detected no contaminants above MCLs; and
- air sampling and monitoring at the TVA site (with more than 60,000 air samples collected) show that particulate levels are below National Ambient Air Quality Standards for all parameters tested. Air monitoring is also being performed to assess air quality conditions for workers whose assigned tasks involve direct contact or close proximity to the coal ash. The sampling results (with more than 3,000 samples collected) show no exceedances of current, established occupational exposure limits.

Oversight of Clean Up Activities

On January 12, 2009, the Commissioner of TDEC issued an order to TVA that among other things required TVA to submit a Corrective Action Plan (CAP) for addressing the clean up of the ash spill and to conduct a root cause analysis to determine the cause of the dike failure. In addition, on February 4, 2009, EPA Region 4 and TDEC sent a letter to TVA notifying TVA that, pursuant to Executive Order 12088, EPA considers the Kingston spill to be an unpermitted discharge of a pollutant under the Clean Water Act. In order to meet the requirements of both the TDEC Commissioner's Order (TDEC Order) and Executive Order 12088, and to ensure the most efficient and expeditious collaboration between the three agencies, the letter directed TVA to provide copies of all plans, reports, work proposals and other submittals to EPA and TDEC simultaneously. EPA and TDEC coordinated reviews and approvals of the submittals within our respective authorities.

TDEC and EPA approved TVA's Phase One Dredging Plan on March 19, 2009. The Phase One Dredging Plan addressed removal of coal ash from the main channel of the Emory River. In conjunction with the dredging operations, TDEC and EPA required TVA to develop an extensive monitoring and sampling plan to monitor any releases that might occur during the dredging operation and prevent additional harm to human health or the environment.

On May 11, 2009, EPA and TVA entered into an AOC. Under the AOC, cleanup, assessment, and restoration activities take place through time-critical and non-time critical removal actions which will be implemented by TVA and overseen by EPA. Components of these actions take place in parallel, and I will discuss the status of non-time critical removal activities later in my testimony. An EPA Region 4 OSC and a Remedial Project Manager (RPM) have been assigned to coordinate and oversee the time-critical and non time-critical actions, respectively. To the extent that additional cleanup activity is needed beyond the anticipated removal work, the AOC commits TVA to perform all additional response activity.

Our objectives under this enforceable AOC are to make sure that the clean up is comprehensive, is based upon sound scientific and ecological principles, moves as quickly as possible, is fully transparent to the public, especially the local community, and meets all federal and state environmental standards.

The EPA/TVA AOC does not replace the TDEC Order, which remains in effect. Our working relationship with the State of Tennessee has been exceptional, and we are committed to continue in that vein. As there are provisions of the TDEC Order and the AOC which overlap

and which are unique to each agency's regulatory authority and responsibility, EPA and TDEC are working to prevent duplication of efforts and give clear direction to TVA in terms of state and federal authority and responsibility.

Time-Critical Removal Action

A primary objective of the time-critical phase of the removal is to recover and manage the major portion of the coal ash in the Emory River to help minimize the potential for flooding and the downstream migration of the coal ash. To date, more than approximately 550,000 CY of coal ash have been dredged or excavated from the area east of Dike 2.

Since entering into the AOC, over a nine week period, TVA increased ash removal operations east of Dike 2 from approximately less than 1,000 CY/day to the current rate of removal at approximately 10,000 CY/day. This has been accomplished through the addition of improved dredging techniques, two mechanical dredging barges, an additional hydraulic dredge, and wet excavation techniques. Larger hydraulic dredges are expected to be operational at the site (replacing the smaller, current dredges) in August. Mechanical dredging will continue to remove debris obstacles and wet excavation techniques will be employed for near shore material. The recovered ash is dewatered and transported to specially constructed on-site temporary storage cells prior to off-site disposal. Currently, there is capacity at KIF for temporary storage of approximately 1.5 million CY of recovered coal ash.

Under the TDEC Order and the AOC, TVA was required to perform a detailed analysis of off-site disposal options for coal ash removed from the Emory River east of Dike #2. Off-site

disposal is necessary to maintain the pace of dredging operations given that there is currently no on-site facility for disposal which meets the requirements of the AOC. TVA began this process in late February 2009 by issuing a request for proposal (RFP) to identify potential off-site disposal facilities for consideration. After reviewing about 25 proposals, three sites accessible by rail and four sites accessible by truck were identified as being immediately available for ash disposal.

Of the three facilities served by rail that answered the RFP, the Arrowhead Landfill located in Perry County, Alabama was identified by TVA as the best facility to receive the coal ash transported off-site during the time-critical removal action. The Arrowhead facility is a Subtitle D landfill that fully meets the requirements of the AOC and is permitted by the Alabama Department of Environmental Management (ADEM). It has a composite liner system consisting of two feet of compacted clay and a high-density geomembrane liner, a leachate collection system, groundwater monitoring, and closure and post-closure care provisions. The landfill has more than 10 million CY of storage capacity to accommodate the estimated three million CY of ash to be taken off the site. Additionally, the Arrowhead Landfill is served directly by the Norfolk Southern rail line which helps reduce traffic congestion, reduce air impacts, is considered more fuel efficient, and decreases the need for road repair that would be necessary if trucks were used to transport the coal ash.

Prior to approving the Arrowhead Landfill as the disposal site for the coal ash, EPA met with ADEM to discuss the landfill, visited the landfill itself, and met with local leaders and members of the surrounding community to review the disposal plan and answer questions.

Elected community leaders actively supported the Arrowhead Landfill as a potential site for disposal of the coal ash.

On July 2, 2009, EPA approved TVA's selection of the Arrowhead Landfill, which meets the CERLA Off-site Rule. Transport of coal ash from KIF to the facility began on July 2, 2009, and as of July 15, 2009, eight shipments totaling more than 60,000 tons of coal ash have been transported to the landfill for final disposal.

Non Time-Critical Removal Activities

Non time-critical removal actions are a means under Superfund to address situations involving the release or threatened release of hazardous substances or contaminants into the environment when there is planning time of at least six months prior to the initiation of site activities. Aspects of the KIF coal ash release and cleanup being addressed under the non time-critical removal include residual coal ash remaining in the Emory River after completion of time-critical dredging, coal ash released to embayments west of an on-site structure known as Dike #2, restoration activities, investigation of human health and ecologic risks, and natural resource impacts. As I noted earlier, an EPA Region 4 RPM has been assigned to coordinate and oversee the planning and implementation of non time-critical removal activities.

Alternatives for achieving the objectives of the non time-critical removal are identified and evaluated through an Engineering Evaluation/Cost Analysis (EE/CA). Under the terms of the AOC, TVA is to submit to EPA a draft work plan for performing one or more EE/CAs within 90 days of the May 11, 2009, effective date of the AOC. The work plan will detail the activities

to be performed in developing the EE/CA, including the media to be investigated, data quality objectives, and the methodologies for human health and ecological risk assessments. Following completion of the work to be performed under the work plan, TVA will submit a draft EE/CA report for EPA review and approval. Upon issuance of a final EE/CA, TVA will make the EE/CA and the accompanying Administrative Record available for public comment in accordance with provisions in the National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan (NCP). Once public comments have been addressed, TVA will submit to EPA an Action Memorandum that responds to public comments and describes the selected response actions under the non time-critical removal. Following EPA approval of the Action Memorandum, TVA will submit a work plan for implementation of the selected response actions.

An EE/CA Technical Work Group (Work Group) has formed and held two meetings to begin preparations for the non time-critical activities. The Work Group consists of representatives from EPA, TVA, TDEC, the U.S. Fish and Wildlife Service and Department of Interior, the Tennessee Department of Health, and the Tennessee Wildlife and Resources Agency. It is the aim of the Work Group to have the EE/CA ready for implementation when the time-critical removal nears completion in order to continue work without a break in operations.

Impoundment Structural Integrity Assessments

As noted in previous testimony provided to the Subcommittee, the failure of the ash impoundment at TVA's KIF in December 2008 highlighted the issue of impoundment stability. As a result, EPA began a major effort to assess the stability of those impoundments and other

management units which contain wet-handled coal combustion residuals (CCRs). Our assessment has three phases: information gathering through an information request letter; site visits or independent assessments of other state or federal regulatory agency inspection reports; and final reports and appropriate follow up.

EPA is making progress with our assessment of these impoundments. Currently, we are finalizing our review of the responses to the CERCLA 104(e) letters that were sent. Overall, the assessment responses from more than 200 facilities identified more than 500 management units. We expect to post that information to the EPA website within the next 6-8 weeks. In the meantime, EPA staff and contractors are in the field conducting on-site visits and inspections of those management units reported as being "high" or "significant" hazard potential while also reviewing any current dam safety reports available from the States or the facilities. A hazard potential rating, which EPA is using to screen facilities for visits and inspections, is not related to the stability of the management unit or impoundment, but to the potential for and extent of harm likely to occur should the impoundment fail. If our assessments, which do include a study of whether each particular high or significant hazard impoundment is stable, indicate that corrective measures are needed, EPA will work with facility owners and operators, and our state partners to ensure that these measures are taken. In addition, EPA expects to prepare a report for each of the units assessed and make those reports available to the public. Our goal is to complete all of the assessments for dams with high and significant hazard potential ratings this year. We will continue to share information about our assessment efforts as they progress.

The components of EPA's impoundment assessments are based on the scope of work that was prepared before the TVA Kingston root cause analysis was completed. EPA staff who are managing our dam integrity assessments have reviewed the TVA Kingston root cause analysis. The issues it raises are the kinds of issues and concerns EPA's contractors are looking for in the field when assessing the units in which CCRs are being managed. The study confirms our initial understanding that it is important to have the dam designed by a Professional Engineer, geotechnical studies should be conducted, and the construction should be under the design and supervision of a registered Professional Engineer.

In addition, EPA continues to evaluate CCR disposal practices at coal-fired power plants to determine if these facilities are in compliance with existing federal environmental laws and will take enforcement action, where appropriate, to address violations.

Conclusion

EPA recognizes that the coal ash release in Kingston was a devastating event for the community and that many of its members are dealing with very difficult changes in their daily lives, their homes, and their property. EPA will use its authorities and expertise to continue oversight and technical assistance efforts to protect human health and the environment during the clean up of this catastrophic release and promote the restoration of the surrounding ecosystem. During the response efforts, EPA will continue its regulatory development process and its management unit assessment efforts and will continue to keep the Committee informed on progress related to these efforts.

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July 22, 2009

Mr. Jimmy Miller
Subcommittee on Water Resources and Environment
2165 Rayburn House Office Building
Washington, DC 20515

Subject: Written Materials for Mr. Walton's Testimony for July 28, 2009 Appearance before Subcommittee on Water Resources and Environment

Dear Mr. Miller,

As requested in a letter from the Honorable Eddie Bernice Johnson, M.C., Chairwoman of the Water Resources and Environment Subcommittee of the U.S. House of Representatives, Committee on Transportation and Infrastructure, dated July 15, 2009, we are providing you with 75 color copies of the updated Executive Summary excerpted from AECOM report on the Root Cause Analysis of the TVA Kingston Dredge Pond Failure dated June 25, 2009, as our written testimony submission, and 75 color copies of Mr. Walton's PowerPoint presentation that he will be presenting to the Subcommittee at 10:00 a.m. on July 28, 2009. We are also submitting under separate cover to Ms. Jenna Tatum an electronic copy of the PowerPoint presentation you requested. We may abbreviate the PowerPoint presentation to accommodate the time available for our testimony. We respectfully request an LED projector and appropriate lighting to allow for the audience to view the presentation.

We are also sending 20 paper copies of the Executive Summary and PowerPoint presentation to Ms. Jenna Tatum at Room B-376 Rayburn House Office in Washington, D.C.

Please call Mr. Bill Walton at (847) 279-2493 or Mr. Bill Butler at (920) 406-3168 if have any questions or if we can be of further assistance to you.

Respectfully yours,

William Butler

William Butler, P.E.
Senior Geotechnical Engineer

William H. Walton

William H. Walton, P.E., S.E., F.ASCE
Senior Principal Engineer and Vice President

Attachments
Executive Summary (75 copies)
PowerPoint Presentation (75 copies)

cc: Mr. Ralph Rogers -TVA (cover letter only)

AECOM July 23, 2009

Executive Summary for Root Cause Analysis of Kingston Dredge Cell Failure

The failure occurred around 1:00 a.m. EST, on Monday, December 22, 2008, when the north and central portions of Cell 2 at the Kingston Fossil Plant ash disposal site suddenly failed. An estimated 5.4 million cubic yards of material, consisting primarily of hydraulic-filled ash and intermediate stage containment dikes, were released in a progressive sequence of flow slides over a period of approximately one hour. Ultimately, the flow slide would extend northward approximately 3,200 feet beyond the limits of the original ash pond over the Swan Pond Creek flood plain, a back water slough of the Emory River and into the former Emory River Channel of Watts Bar Reservoir. Prior to reaching the Emory River channel, the slide mass inundated several TVA-owned sloughs, spread onto eight acres of private property and damaged several structures.

Background Information

The land surrounding the power plant is undeveloped and only sparsely populated. The disturbance created by the slide created a flood water response wave that ran upstream and downstream of the surrounding waterways. The combined mass of flowing ash and water pushed one single-family home entirely off its foundation, and ultimately rendered three structures uninhabitable. It is estimated that as many as 42 residential properties may have been affected. A reported 22 residences were evacuated, but no injuries or individuals in need of hospitalization were identified.

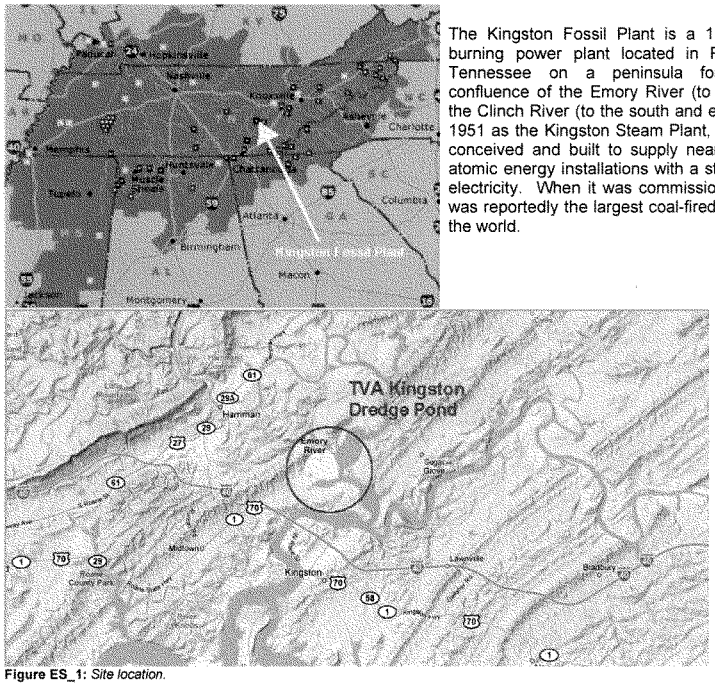


Figure ES_1: *Site location.*

The Kingston Fossil Plant is a 1,700-MW coal-burning power plant located in Roane County, Tennessee on a peninsula formed by the confluence of the Emory River (to the north) and the Clinch River (to the south and east). Begun in 1951 as the Kingston Steam Plant, the facility was conceived and built to supply nearby Oak Ridge atomic energy installations with a steady supply of electricity. When it was commissioned in 1955, it was reportedly the largest coal-fired power plant in the world.

Site History and Chronology of Dredge Cell Development

Water for the Tennessee Valley Authority (TVA) Kingston plant is drawn from the reservoir created by the Watts Bar Dam which is located midway between Knoxville and Chattanooga, roughly 38 miles downstream from the mouth of the Clinch River. Construction of Watts Bar Dam began in 1939, it was completed in 1942, and it is one of nine TVA dams on the Tennessee River. The reservoir stretches approximately 72 miles along the Tennessee River, and it creates a slack-water reservoir with channels that extends more than 20 miles up the Clinch River and 12 miles up the tributary Emory River. The failed dredge cells are located two miles up the Emory River from its historic confluence with the Clinch River.

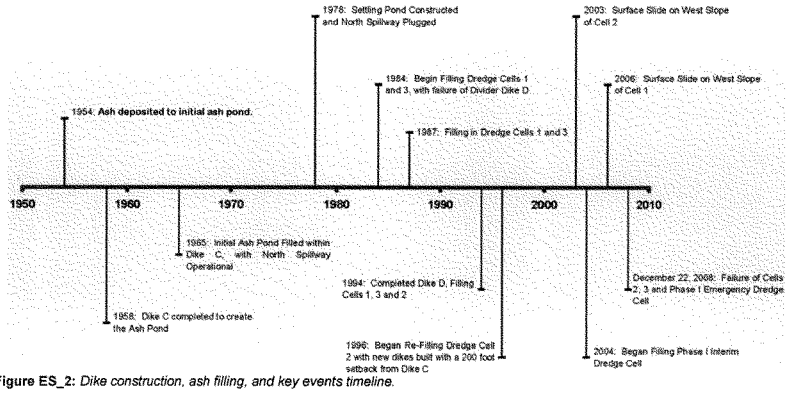


Figure ES_2: *Dike construction, ash filling, and key events timeline.*

The initial 1954, 85-acre ash pond and more expansive 275-acre final storage area, completed in 1958, are located immediately north of the Kingston Fossil Plant along the bank of the former Emory River at the confluence with Swan Pond Creek and its flood plain. The 275-acre storage area consists of the main pond where ash is deposited and a stilling pond where process water can settle out fine-grained material and decant water back to the Reservoir. Once the initial ash ponds were full in the early 1980s, the TVA began to dredge ash from a collection pond and to construct elevated dredge cells with containment dikes where ash from the main pond is finally placed. Between 1954 and 1990, the loose wet ash placed in the dredge cells accumulated to a depth of 40 to 65 feet. Figure ES_3 shows an aerial photograph of the site with key features labeled.

The Portland Cement Association describes flyash as a finely divided residue that results from combustion of pulverized coal in electric power generating plants. During combustion in a conventional plant, mineral impurities within the coal (e.g., clay, feldspar, quartz, and shale) fuse in suspension and, as they cool, solidify into flyash which is primarily silicate glass. The flyash is separated and collected from the combustion exhaust gas and hydraulically pumped through pipes to the ash ponds. When viewed through a scanning electron microscope, the majority of flyash particles are revealed to be solid spheres and hollow cenospheres.

Engineered red earthen perimeter dikes named "East Dike" and "Dike C" were constructed between 1951 and 1958 on alluvial flood plain deposits of clay, silt, and sand. These dikes create the initial impoundment which has come to be known as the ash pond. The clay, silt and sand alluvium under the ash pond extends between approximately 20 and 40 feet to the Conasauga Shale. The Conasauga Shale is a Cambrian-aged formation that consists of folded and fractured shales with minor layers of limestone and dolomite. The Conasauga extends into Alabama, Georgia and Virginia. The shale is not locally karstic and artesian conditions have not been observed for the formation.

TABLE ES_T1: Typical Subsurface Profile at top of North Dredge Cell 2

Log	Thickness (ft)	Profile Depth (ft)	Description
	0-90	90	Loose Ash Fill
	< 0.5	90	Slimes
	0 to 15	90 to 105	Clay and Silt Alluvium
	10 to 20	110 to 125	Silty Sand and Silt Alluvium
	Greater than 50 feet	125+	Conasauga Shale

Prior to 1958 before Dike C was completed to fully contain the ash pond, the ash stream was discharged directly to the Watts Bar Reservoir. The slurry of ash and water naturally flowed out across the floor of the storage area. Although well mixed and turbulent at the point of discharge next to the power plant, the ash stream eventually became stagnant in the containment area and the suspended solids began to precipitate out in a deltaic manner. What resulted was a thin (less than about six-inches thick) laminated structure of interbedded flyash, eroded dike soils and re-deposited river sediments within the footprint of the future ash storage cell. The spillway for this containment pond operated from 1958 to 1977 and was located at the north end of Dike C 5,200 feet from the point discharge next to the plant. This small grained material is referred to as "slimes" as this term applies to the fine-size sediments having a slippery, viscous feel. The thin laminated layer at the base of the dredge cell will be described as a soft sensitive slime for the purposes of this study. AECOM did not find slimes under Dredge Cell 1 or the Phase 1 Emergency Dredge Cell during our exploration likely due to over-excavation of ash in 1984 and being closer to the point of discharge.

The ash storage pond was originally shown on engineering drawings prepared by the TVA in 1951. Modifications and additions to increase the original storage capacity of the ash ponds were made throughout the decade of the 1970's. By 1985, Dike C was being raised for the third and final time. A few isolated outbreaks of seepage had been observed over the years on the Dike C perimeter dikes, and stability analyses at the time indicated that any additional expansion next to the Dike C reservoir alignment would require a setback from the original storage pond limits to reduce seepage forces acting on the dikes.

In 1995, TVA designed and began construction of a vertical dredge cell expansion program that was permitted in 2000. A Solid Waste Permit was issued by the Tennessee Department of Environment and Conservation (TDEC) to raise Dredge Cells 1, 2, and 3 using upstream dike construction methods to form an approximately 120-acre sluiced ash storage structure. In this process, small perimeter dikes are constructed in stages, with the subsequent dikes bearing on the lower dikes and a portion of each perimeter dike placed over previously sluiced ash, as a set-back to flatten slopes. The compacted dikes include an internal seepage control system and are usually constructed one stage in advance of filling. The dikes step inward as the overall height of the cell increases on an average slope of four horizontal to one vertical. Because the plan area of cells decreases with each inward step of the dikes, the available storage area of the cell decreases as the height increases. Assuming the placement volume remains constant, the rate of vertical expansion of the cell increases over time. The raising program of the cells designed in 1995 was planned to be complete by 2014.

A shallow slide with a small release of sluiced ash occurred on the west side of Dredge Cell 2 in 2003 and small seepage outbreaks were observed in 2006, which were followed by remedial efforts to contain and collect seepage. Plans for a three phase lateral and vertical expansion program of the dredge cells were prepared between 2004 and 2006 to extend the design life of the ash storage facility beyond 2014. TDEC-permitted construction and filling of the Phase 1 Emergency Dredge Cell was performed between 2004 and 2007, and Phase 2 lateral expansion cell was subsequently discharged to in 2007 and 2008. From October 16 to December 18, 2008, TVA reported that 100,000 cubic yards of ash material was placed within the 31-acre Dredge Cell 2. For the plan area at the time, the placement vertical fill height rate is estimated to be approximately 6 feet/year.

Between November 20 and December 21, 2008 meteorological records indicate that no more than 8 inches of rain fell on the ash storage site. Early December rains swelled the reservoir by approximately 3 feet, but by December 21, it had been lowered to pre-rainfall level, well within normal operating limits of the reservoir. Approximately 1-inch of rain was reported for the day prior to failure, but inspections at noontime on December 21, 2008 did not observe adverse conditions, evidence of seepage, or shallow instability. It is unlikely that the rainfall had any significant affect on the stability of the structure. The only noted wetness was near water well (WP02), out of several dozen wells along the toe of the west slope of Cell 2. This wet area was noted on December 21, 2008 next to a 2006 seepage repair area. The inspection report from December 21, 2008 did not report evidence of shallow slides, piping, or slope instability at this area.

Failure Scenario

Based on the post-failure explorations, testing and analyses completed by AECOM, the initial failure most likely occurred in the northwest corner of Dredge Cell 2, and it was initially contained within the footprint of the structure defined by perimeter Dike C. Based on photographic evidence of slide planes in undisturbed samples, the slide plane extended as far down as the underlying slimes. Stability analyses indicate that the toe (i.e., the lower margin of the displaced material) of the initial failure mass was initially contained within the 200-foot buffer zone that separates the upstream dike expansion from perimeter Dike C. This initial failure was rapidly followed by a series of progressive failures that ultimately breached Dike C.

In a process termed static liquefaction, loose wet ash behind the breached northwest Dredge Cell 2 began to flow as if it were a viscous liquid. The upstream dikes were carried by ash and displaced laterally across the 200-foot setback area comprised of a 40-foot thick layer of old sluiced ash and along with liquefied ash, thrust up against perimeter Dike C, which slid north and west over the alluvial clay deposit at its base. Sloughs 1 and 2 north of the ash pond, were overrun by an outpouring of fluid and dike fragments that created an estimated 47-foot high flood wave or seiche that extended across the backwater slough or tail water of the relocated Swan Pond Creek and up the north hillside, into east Slough 3 which is a backwater channel off the reservoir, and then into the former Emory River channel. Fragments of Dike C and the water wave from the breach pushed the Schean home off its foundation and onto Swan Pond Circle. A telephone call, apparently from the Schean's, was the first documented public notice of the failure.

The scarp of the initial failure began to sequentially progress backwards in Cell 2 as the wet ash lost strength and liquefied. To the south, the sequence of failures was halted by the Cell 1 Divider Dike. With each wall failure, greater and greater volumes of ash were released, triggering still more progressive failures from north to south. At its peak, the slide mass had sufficient volume and energy to extend almost 3,200 feet beyond the limits of breached Dike C up Slough 2 and against the current in the Emory River channel, more than 1,600 feet to the Emory River channel, and nearly 1,000 feet up Slough 3, a side channel to the reservoir. Ash extended almost 500 feet into the reservoir and forced the flow of the Emory River eastward. As a consequence of this failure a portion of the Phase 1 Emergency Dredge Cell lost an upper portion of its contents, but did not experience a deep failure.

Although there has been historic slope and seepage instability along the west side of Cell 2, documented photographic and test boring evidence indicates that dredge cell dike slope instability was shallow and ash inundated rather than undermined Swan Pond Road and the railroad tracks. This is also supported by the fact that many of the AECOM borings conducted along Swan Pond Road showed evidence of only shallow dike and ash instability, while borings conducted 75 feet east Swan Pond Road displayed evidence of deep liquefaction of the ash. The fact that many of the west-facing dike remnants flowed toward the north, on top of ash, as partially intact relics also supports this conclusion that instability did not start along the west slope of the fill.

Based on written witness reports and TVA call logs, the slide event is estimated to have occurred over a span of approximately one hour, with the north side Cell 2 area failing in a sudden and dramatic manner. From AECOM's review of the records and our observations, the failure was very sudden and dramatic, with each successive slide causing rapid movement of the failing mass, with only minimal delay between slides. Survey monuments, a cell phone tower, construction equipment, railroad line, piping, and vegetation were all displaced by the flow. A bulldozer was found almost 1,000 feet from its pre-slide location, and a scraper floated more than 1,200 feet north of the previous day's location. Known cattails in the 200-foot setback next to Dike C north of Dredge Cell 2 moved 3,200 feet north up Slough 2, to an area northwest of the Schean home. Ground shaking, probably from the ash movements during failure was reported at the north end of Cell 1 in the vicinity of the access road which runs

along the left bank of the Emory River. No earthquakes were recorded by local seismic monitoring stations at the time of the failure.

Probable Failure Modes
There were four factors acting together that lead to the Kingston Dredge Cell 2 failure and to the large magnitude of displacements of the failure mass:

1. The dredge cell footprint area became progressively smaller with each dike raise. Therefore, more height was required to store the same annualized ash volume generation, and thus the elevation of sluiced ash was increasing more rapidly. The added height of ash behind the upstream dike construction added load to the wet ash and to the unusual slimes at the dredge cell foundation level. Active Cell 2 at the north side was being raised at rate of 6.1 feet/year. This rate is less than the filling rate of the Phase 1 Emergency Cell that was loaded at a rate of 14.6 feet/year from 2004 to the end of 2006.

2. The 3H:1V sloping upstream dikes with 15-foot wide benches were founded on 35 to 40 feet of wet ash and located 200 feet back from the original containment Dike C. Thus the upstream dikes did not benefit from the better foundation conditions under the original Dike C, where no slimes were found.

3. Creep failure of the loose slimes was occurring under the loose wet ash, reducing the available strength of the slimes. The slimes are unusual in that they are soft, wet, had low shear strength and were susceptible to creep. Figure ES_4 following this Executive Summary shows a photograph of the slide plane in the slimes under Cell 2 in between unfailed clay and failed ash. Based on AECOM's explorations, Cell 2 is underlain by slimes, but slimes were not found in AECOM borings under Cell 1 or under the Phase 1 Emergency Dredge Cell. Cell 1 was closer to the discharge of sluiced ash, thus finer materials such as those observed in the slimes would have been transported further north. The Phase 1 Emergency Dredge Cell was over-dredged in 1984 and the associated failure, likely removed the slimes in this area. This is a likely reason why Cell 1 and the Phase 1 Emergency Dredge Cell did not fail earlier.

4. The initial loose, sluiced ash was placed underwater with a resulting high void ratio with no evidence of consolidation or densification under the weight of fill placed over older ash. As a result, the wet ash remained very loose and susceptible to collapse if subject to rapid loading or rapid displacement. The ash was highly contractive, leading to low undrained strengths with a very sensitive structure (low strain at peak strength). Active ash loading in Cell 2, creep in the weak slimes and limited drainage caused undrained behavior in the loose ash at low strain levels. Ash behavior changed from drained to undrained behavior which leads to very low shear strength in the ash with only slight deformation. This is termed a static liquefaction failure and led to the very large movements of the failure mass.

These four equally rated factors are shown on Figure ES_5.

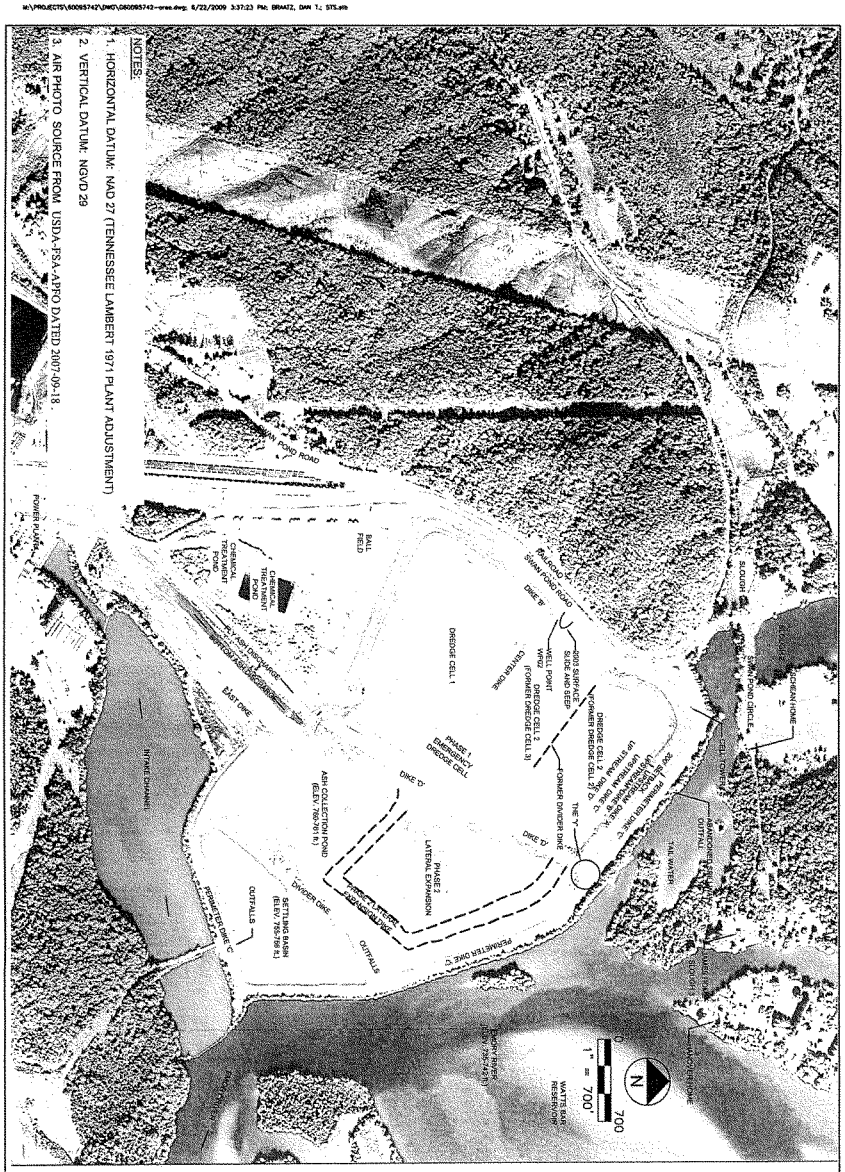
Summary
The north end of Dredge Cell 2 was on the verge of failure due to the high stresses and creep in the loose wet layer of weak slimes. The deformation of the slimes in turn caused the overlying collapsible wet ash to liquefy. Figures ES_6 through ES_11 following this Executive Summary show AECOM's orthographic interpretation of the initial failure location and apparent failure sequence at the north end of Cell 2. Failure of the Kingston dredge cells was sudden and complex in nature due its geographic setting and being built within the Watts Bar Reservoir after the lake was formed. It took a forensic type study to determine the propensity of the ash to liquefy at low strain levels when the material cannot drain and thus becomes undrained, and to locate the slide plane in the unusual, creep susceptible, low undrained shear strength slime layer that underlies Cell 2. In AECOM's opinion, subsurface conditions at the dredge cells were unusual and rarely found. The consequence of failure in the slimes led to the collapse of the dredge cell and loss of the saturated contents of the ash landfill due to the breach of perimeter Dike C. Figures ES_12, ES_13, and ES_14 show AECOM's interpretation of progressive failure at the northwest end of Cell 2 and containment Dike C.

Lessons Learned

The lesson to be learned from the Kingston RCA is not just the identification of the triggering event, which in this case was the slimes in combination with the other three equally important factors, but the progressive liquefaction of the wet ash following the trigger which led to its progressive catastrophic failure scenario. The message applicable to other structures and the industry is the need for containment against a similar flow, regardless of the triggering cause (which could be another kind of weak foundation material subject to going rapidly undrained, or a piping failure, or excess pore water pressure) Each structure is unique and should be analyzed from the perspective of whether its own conditions include potential triggers (of any kind including pore water pressure, seepage, static and seismic forces), and whether the containment is sufficient to retain the ash if it does go undrained and therefore wants to liquefy without sufficient containment to resist fluid pressures and forces.

Prepared by:
William H. Walton, P.E., S.E.
Tennessee P.E. license No. 00110328

Figures ES-3 through ES-14


NOTES:
1. HORIZONTAL DATUM: NAD 27 (TENNESSEE LAMBERT 1971 PLANT ADJUSTMENT)
2. VERTICAL DATUM: NGVD 29
3. AIR PHOTO SOURCE FROM: USDA-FSA-APFO DATED 2007-09-18.
SWAN POND ROAD
RAILROAD
SWAN POND CIRCLE
BALL FIELD
CHEMICAL TREATMENT POND
DIKE B
DREDGE CELL 1
DREDGE CELL 2 (FORMER DREDGE CELL 3)
DREDGE CELL 3 (FORMER DREDGE CELL 2)
2008 SURFACE SLIDE AND SEEP
WELL POINT
VPFD
CENTER DIKE
FORMER DIVIDER DIKE
THE 'Y'
DIKE A
DIKE D
PHASE 1 EMERGENCY DREDGE CELL
ASH COLLECTION POND (ELEV. 760-761 ft.)
PHASE 2 LATERAL EXPANSION
DIVIDER DIKE
SETTLING BASIN (ELEV. 755-756 ft.)
OUTFALLS
PERIMETER DIKE C
EAST DIKE
INTAKE CHANNEL
POWER PLANT
SLUICE
HAL WATTS RESERVOIR
1" = 700'
700
N
SITE FEATURE MAP
ROOT CAUSE ANALYSIS
TVA KINGSTON DREDGE CELL FAILURE
ON DECEMBER 22, 2008
KINGSTON FOSSIL PLANT
HARRIMAN, TENNESSEE
AECOM
Drawn: DTB 6/12/2009
Checked: LWB 6/12/2009
Approved: WWW 6/12/2009
PROJECT NUMBER 60095742
FIGURE NUMBER ES-3

Photos of Slide Plane in Slimes at 09-104B

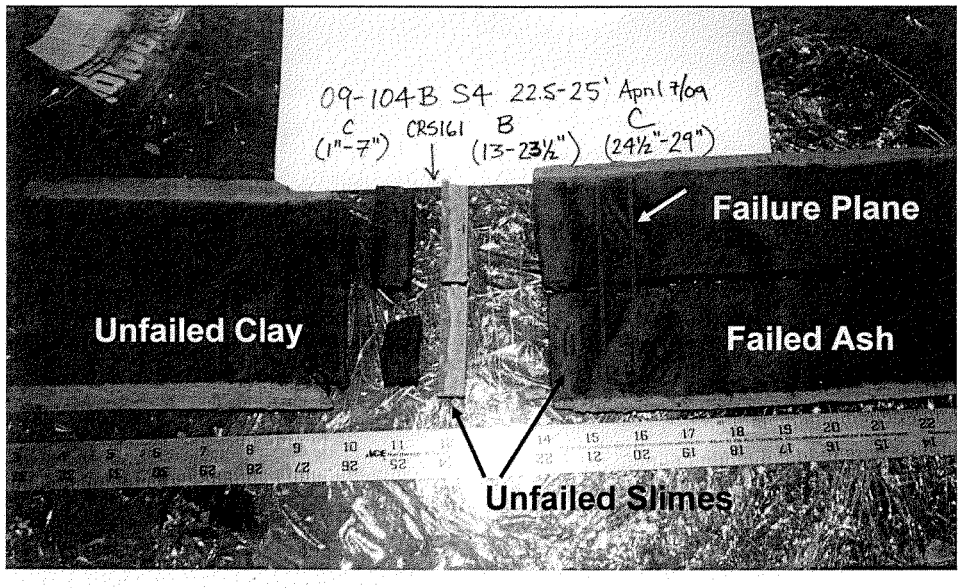
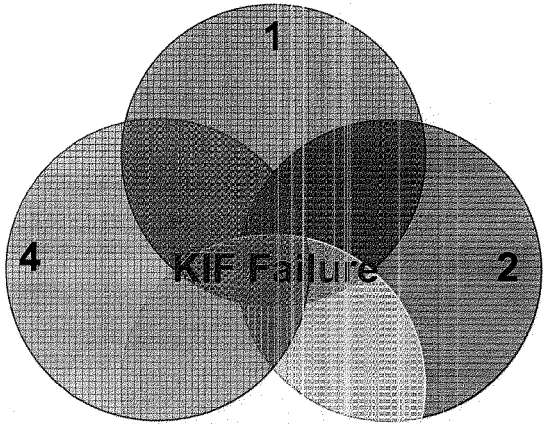


Figure ES_4

Kingston Dredge Cell Failure Conditions

AECOM Report

Increased Loads Due to Higher Fill

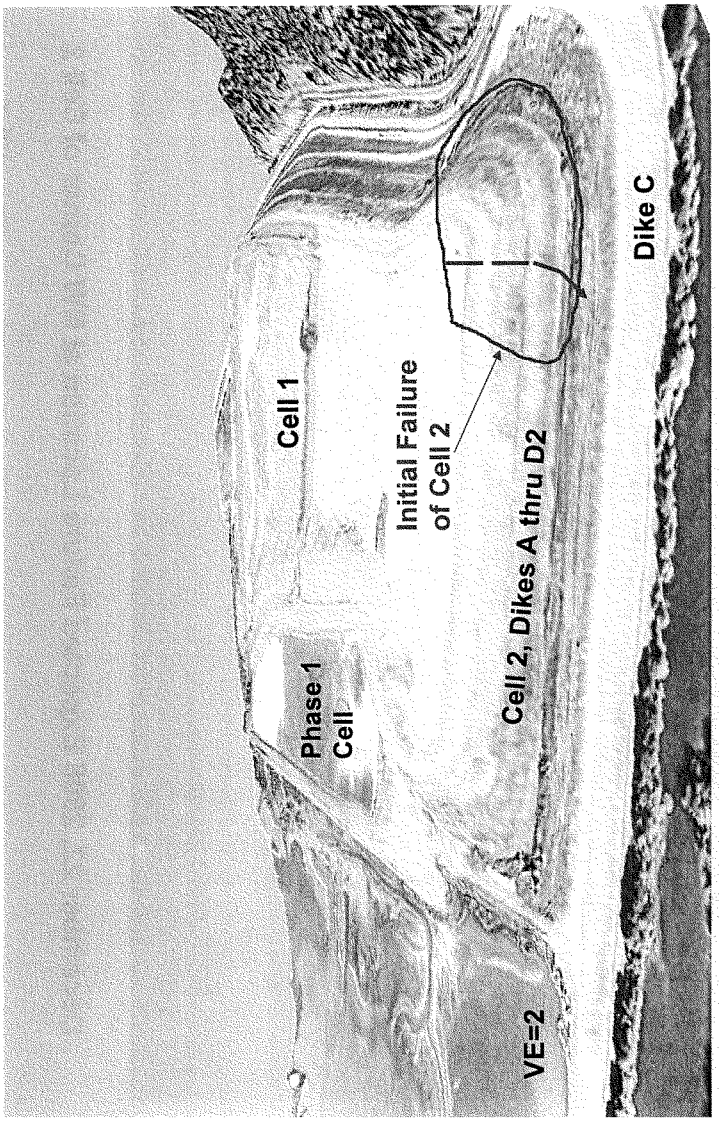


Hydraulically Placed Loose Wet Ash

Fill Geometry & Setbacks

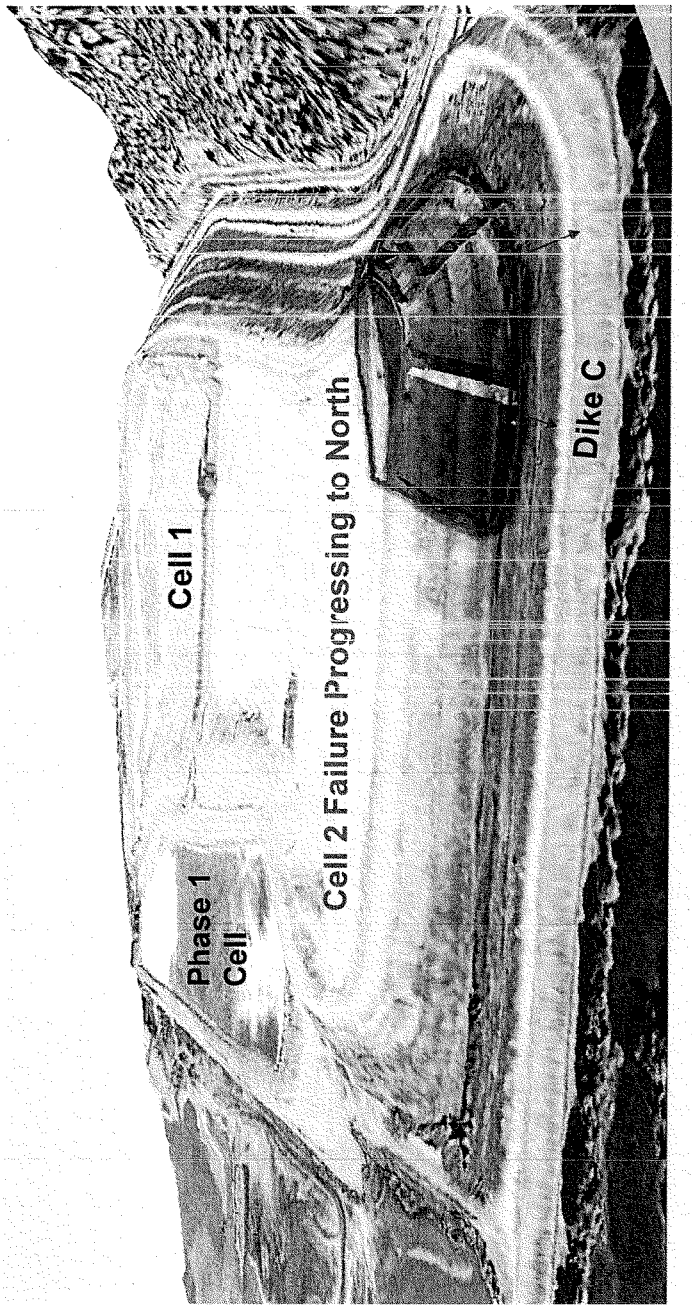
<u>Unusually</u> Weak Slimes Foundation

Figure ES_5



December 22, 2008 Expected Failure Location at NW Corner of Cell 2

Figure ES_6



December 22, 2008 Expected Failure Location at NW Corner of Cell 2

Figure ES_7

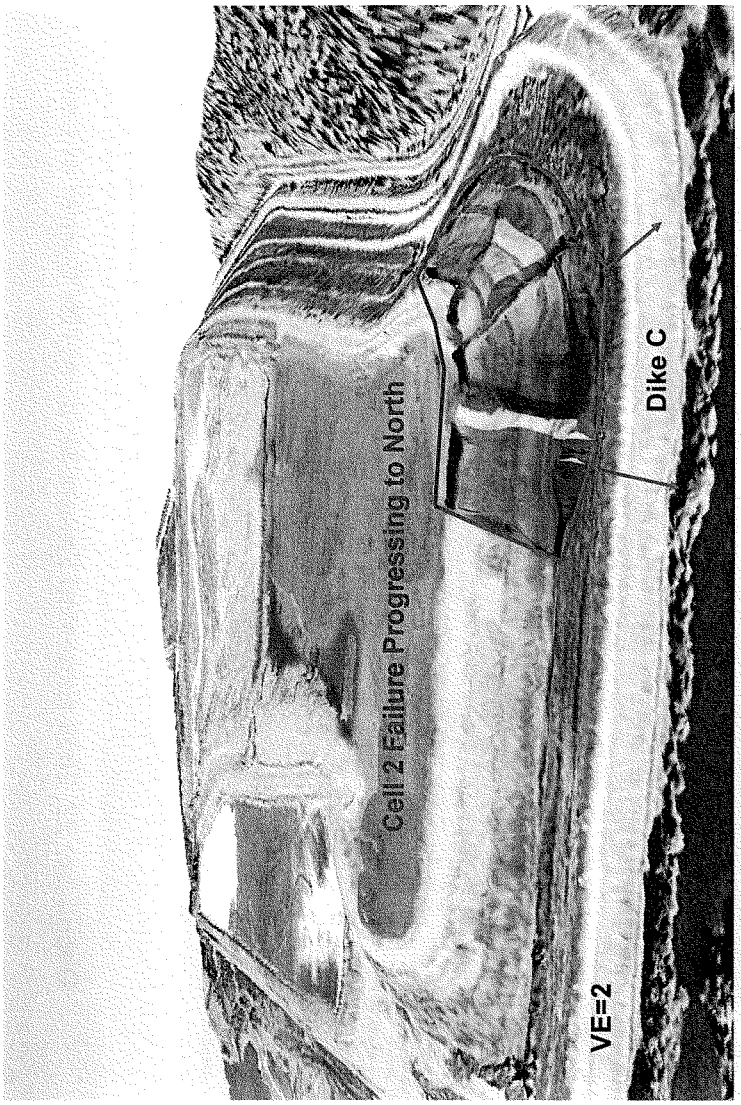
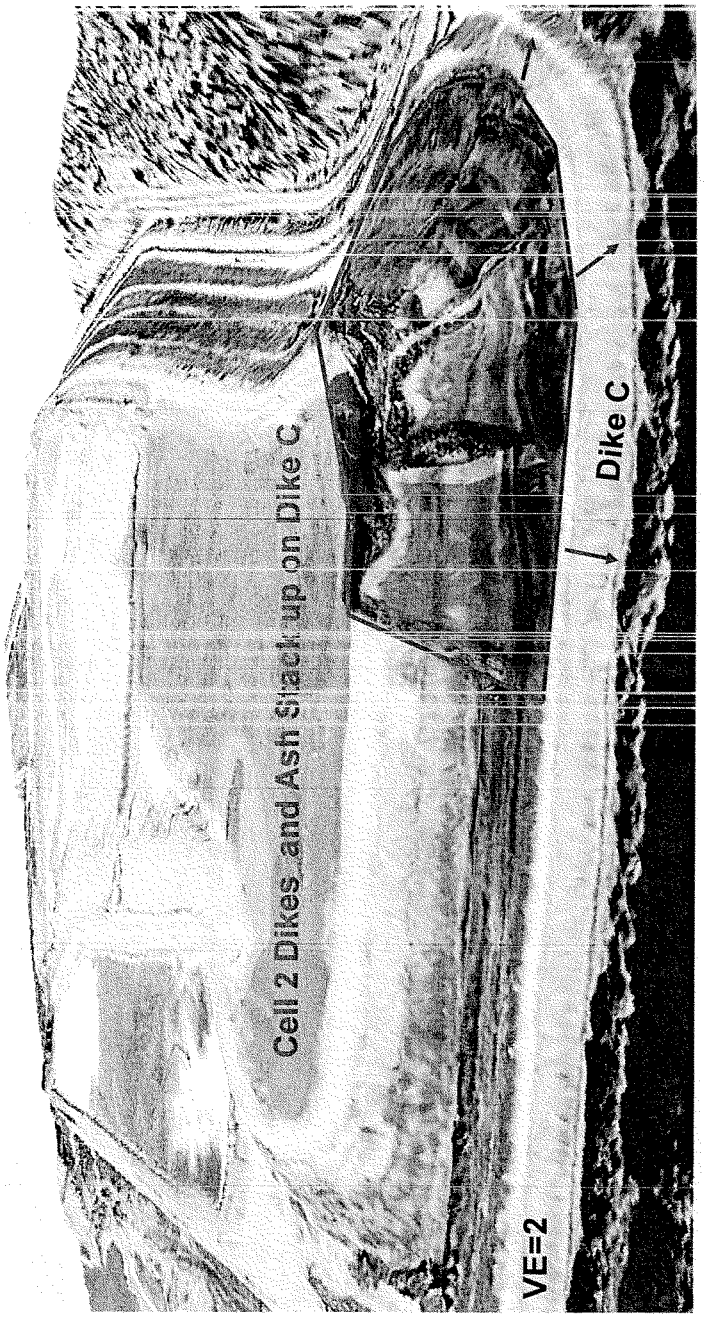
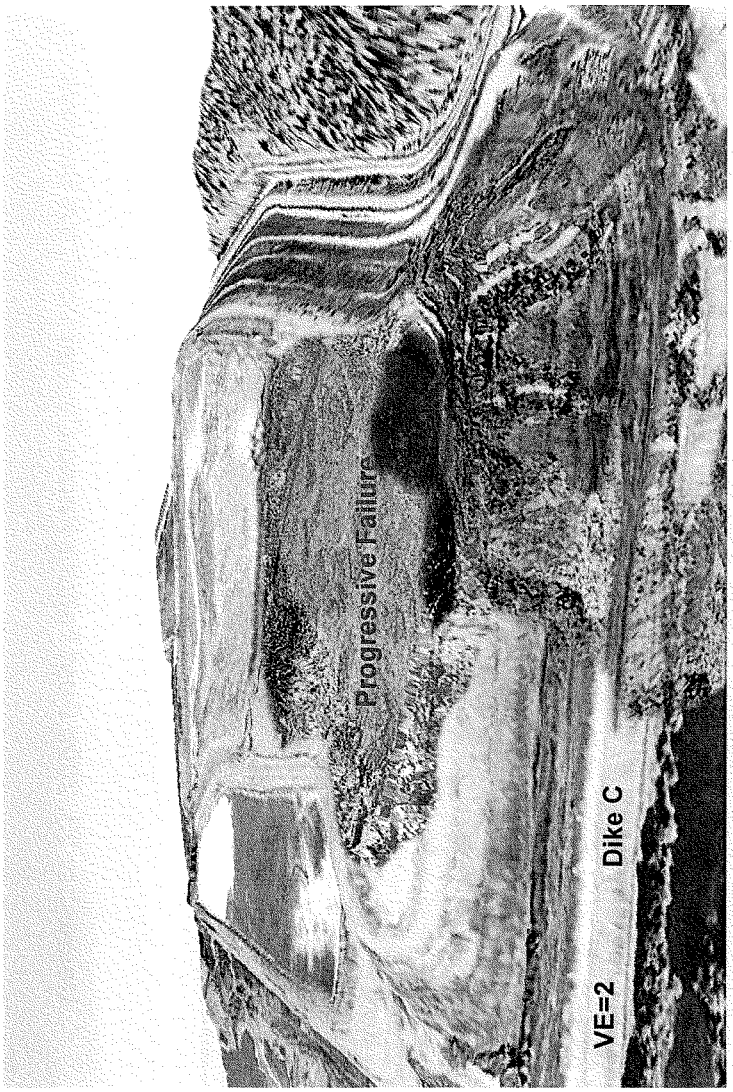

Cell 2 Failure Progressing to North
Dike C
VE=2
December 22, 2008 Expected Failure Mode at NW Corner of Cell 2

Figure ES_8



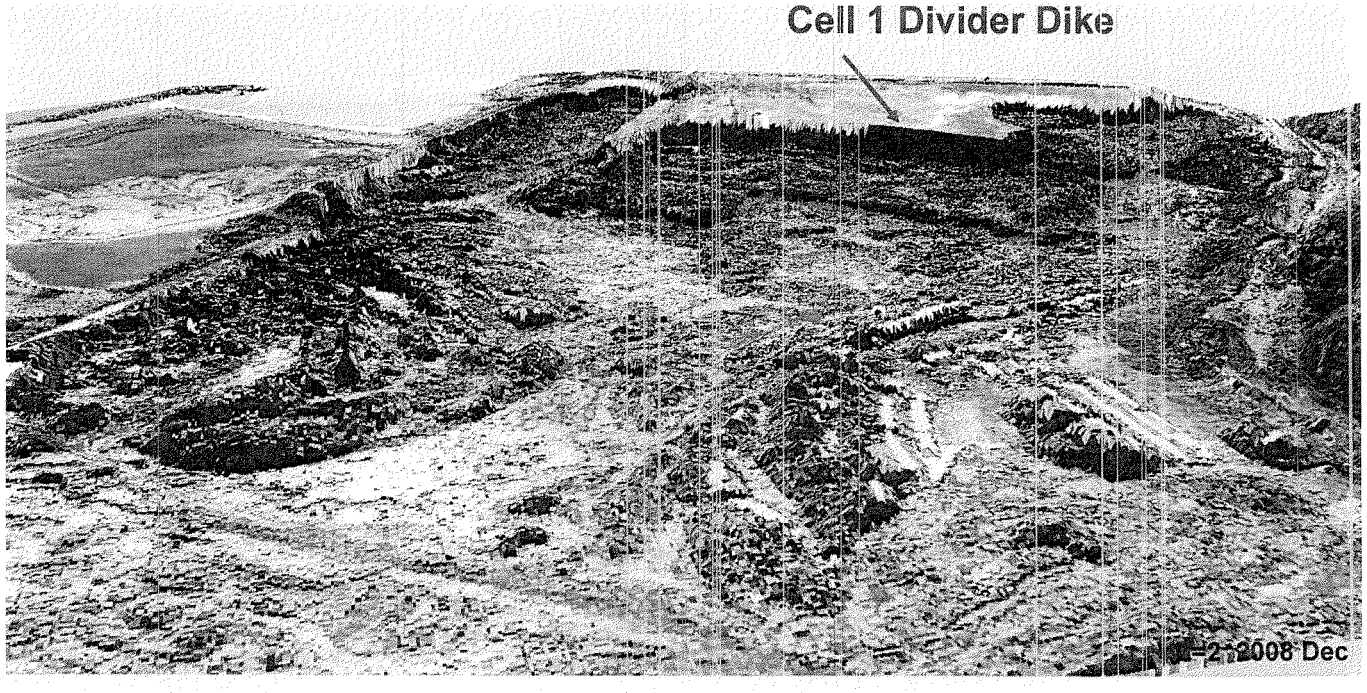
December 22, 2008 Expected Failure Mode at NW Corner of Cell 2

Figure ES_9



December 22, 2008 Expected Failure Mode at NW Corner of Cell 2

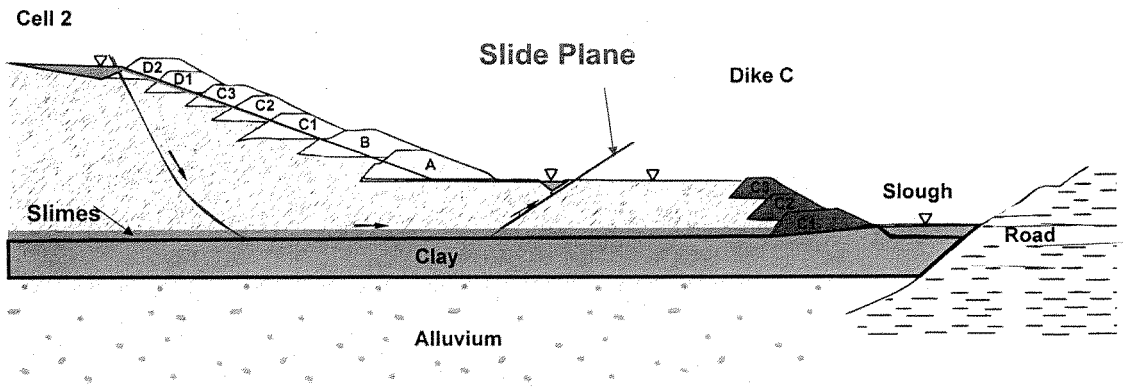
Figure ES_10



December 23, 2008 Post Failure Photo Overlaid on TVA Surveys

Figure ES_11

Stage 1 - Initiation of Failure at North Side of Dredge Cell 2



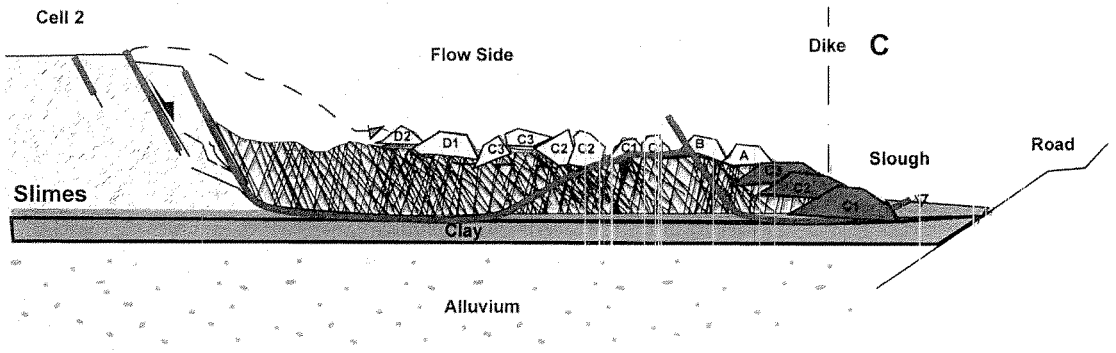
Looking West

AECOM

TVA KINGSTON DREDGE CELL FAILURE 12-22-2008
KINGSTON FOSSIL PLANT
HARRIMAN, TENNESSEE

Figure ES_12

Stage 2 – Ash & Dikes A thru D2 Pile Up Against Dike C. This Surcharge and increased Ash Pressure Causes Dike C to Fail



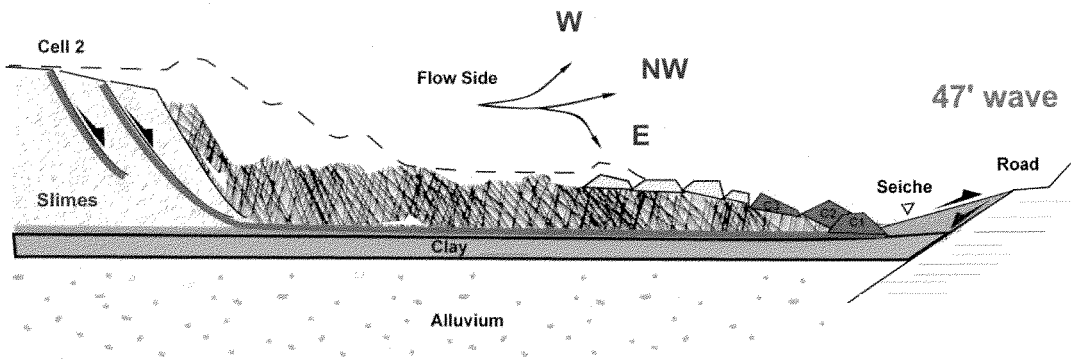
Looking West

AECOM

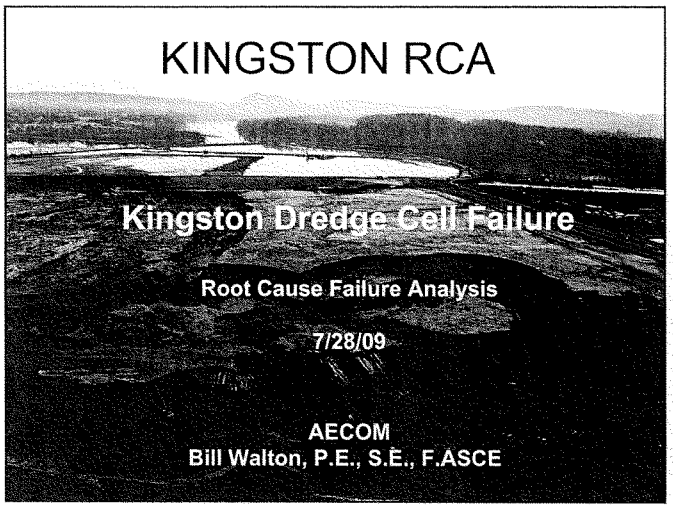
TVA KINGSTON DREDGE CELL FAILURE 12-22-2008
KINGSTON FOSSIL PLANT
HARRIMAN, TENNESSEE

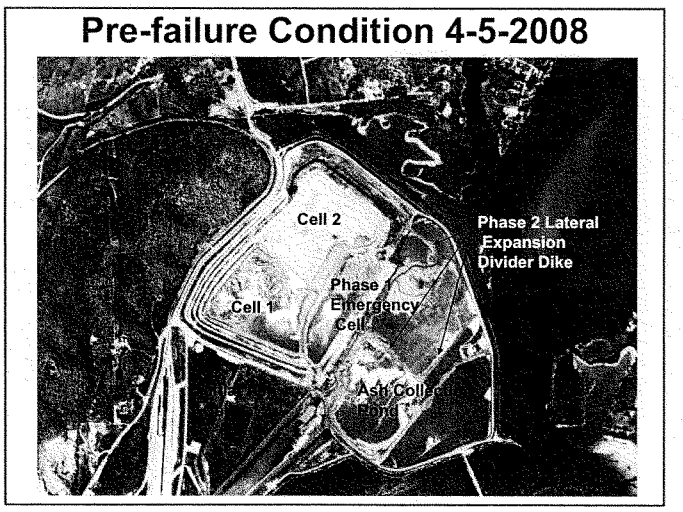
Figure ES 13

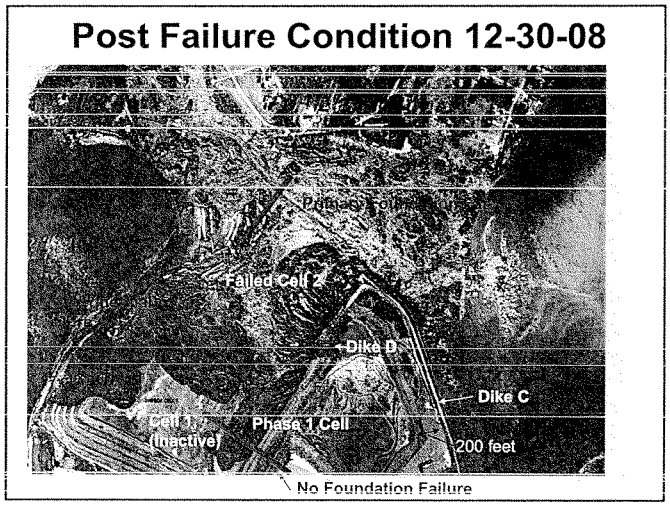
Stage 3 – Progressive Failure Southward that Fails North Dikes A thru D2 Back to Cell 1 Divider Dike. 5.4 Million CY Fill Sloughs and Reservoir

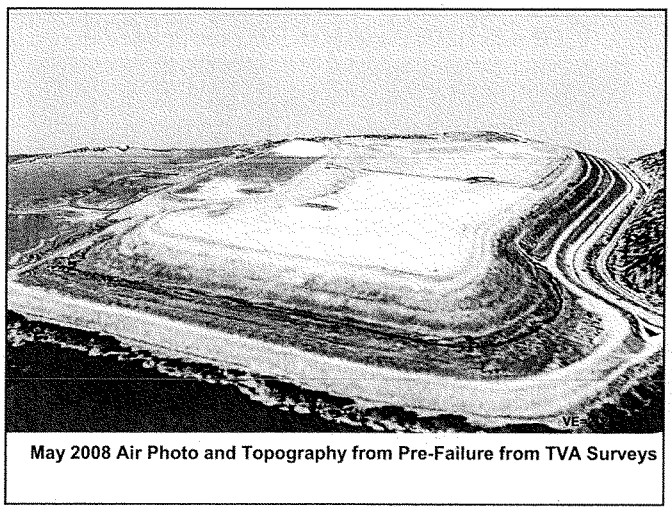


Looking West

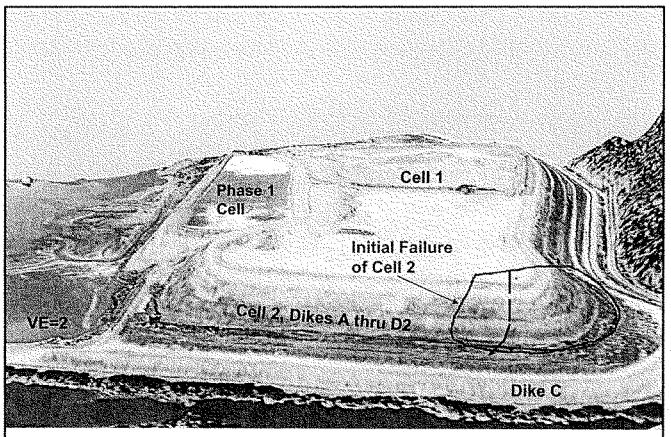

KINGSTON RCA
Kingston Dredge Cell Failure
Root Cause Failure Analysis
7/28/09
AECOM
Bill Walton, P.E., S.E., F.ASCE


Pre-failure Condition 4-5-2008
Cell 2
Phase 2 Lateral Expansion Divider Dike
Phase 1 Emergency Cell
Cell 1

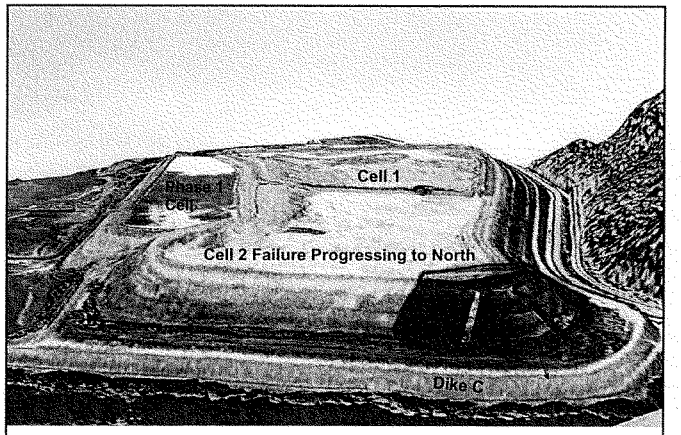




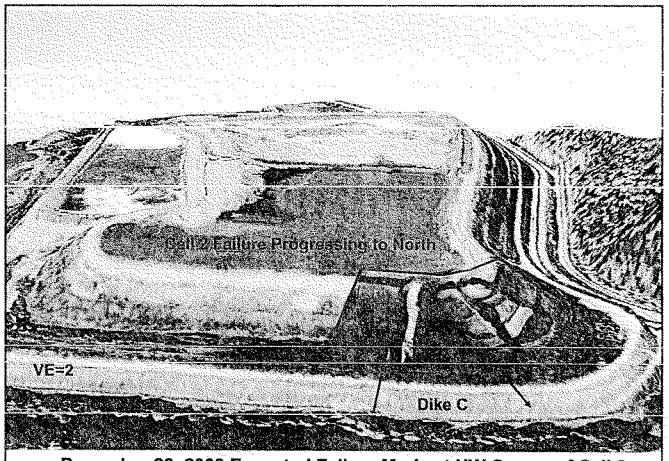
May 2008 Air Photo and Topography from Pre-Failure from TVA Surveys



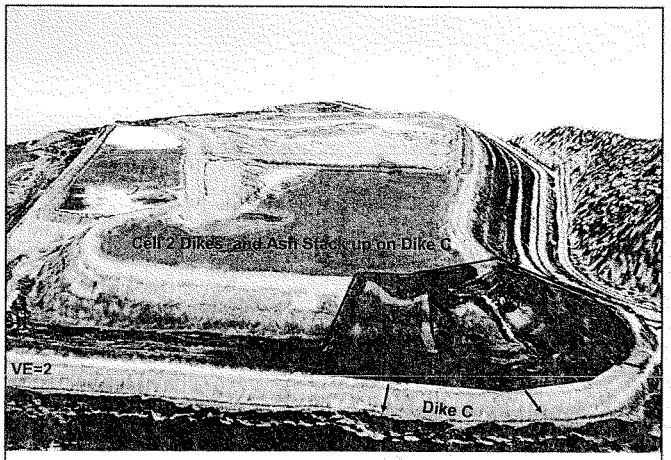
December 22, 2008 Expected Failure Location at NW Corner of Cell 2



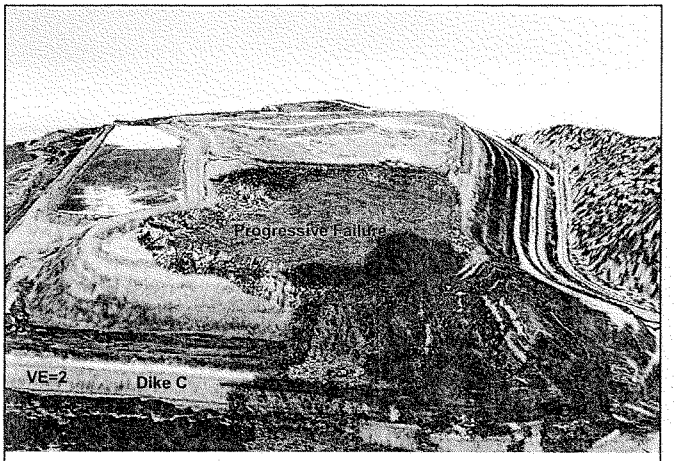
December 22, 2008 Expected Failure Location at NW Corner of Cell 2



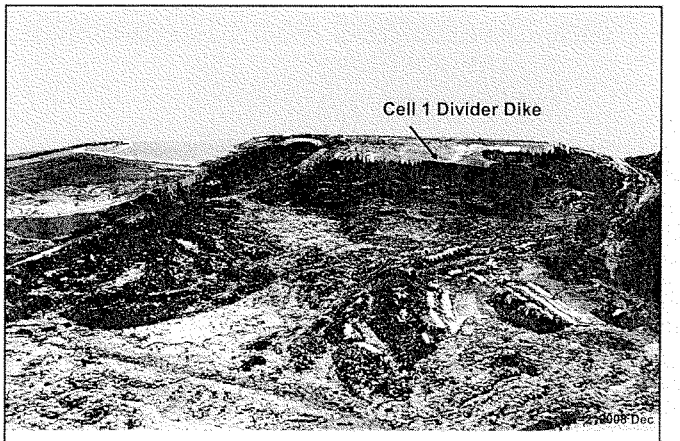
December 22, 2008 Expected Failure Mode at NW Corner of Cell 2



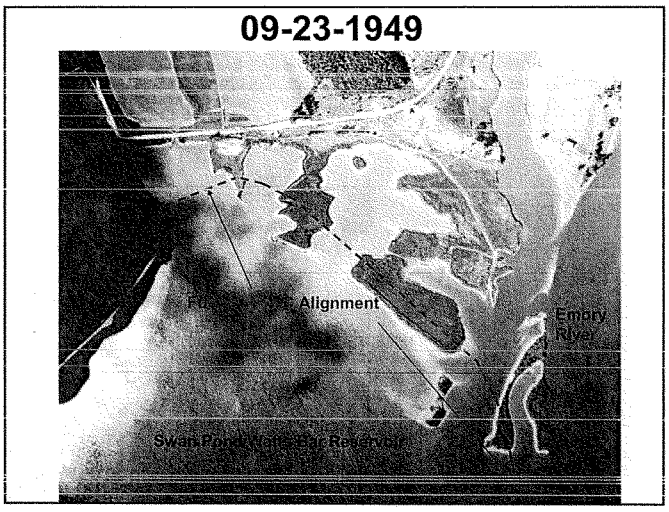
December 22, 2008 Expected Failure Mode at NW Corner of Cell 2

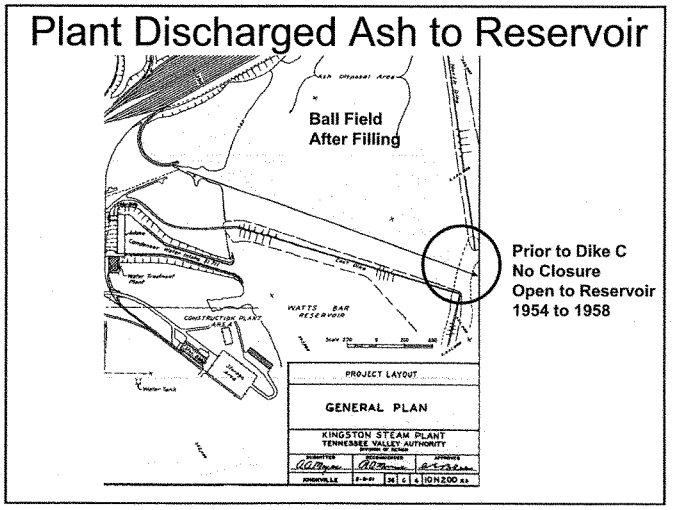


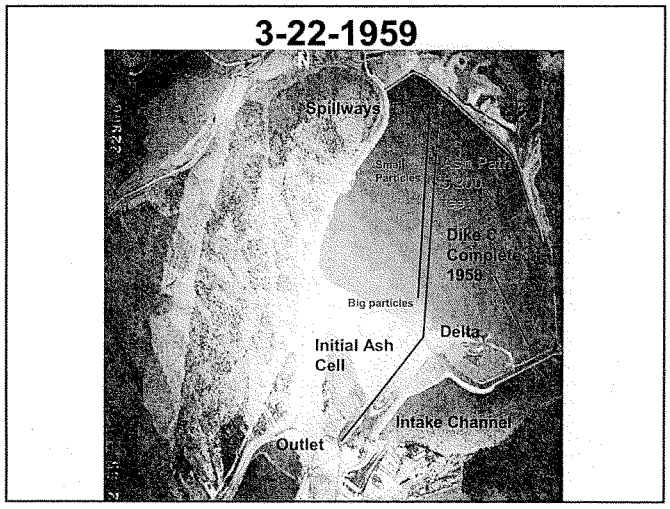
December 22, 2008 Expected Failure Mode at NW Corner of Cell 2

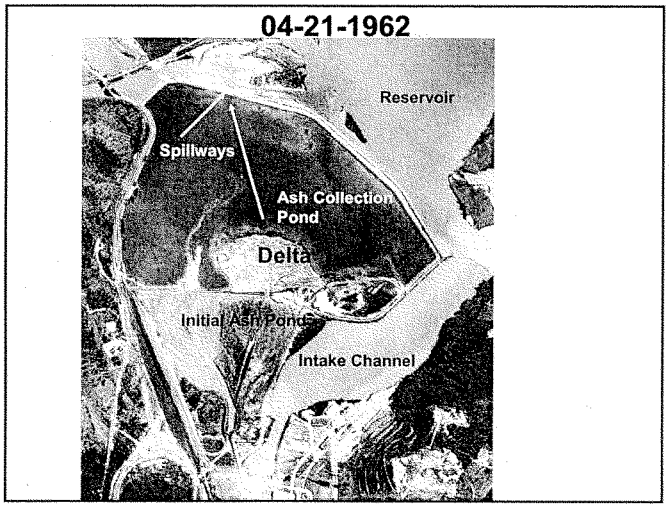


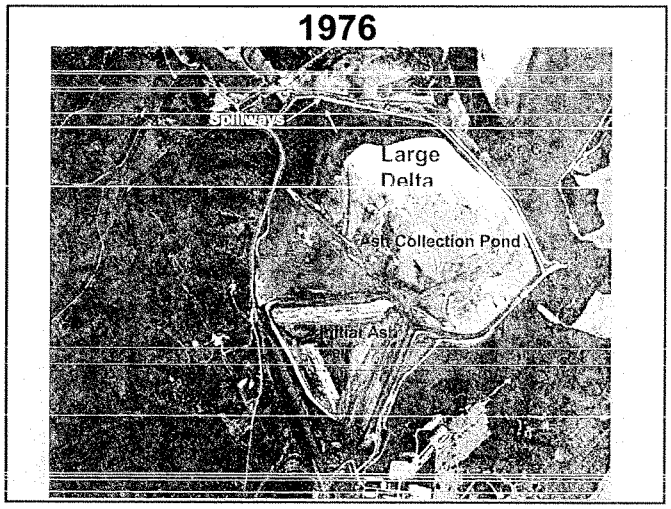
December 23, 2008 Post Failure Photo Overlaid on TVA Surveys

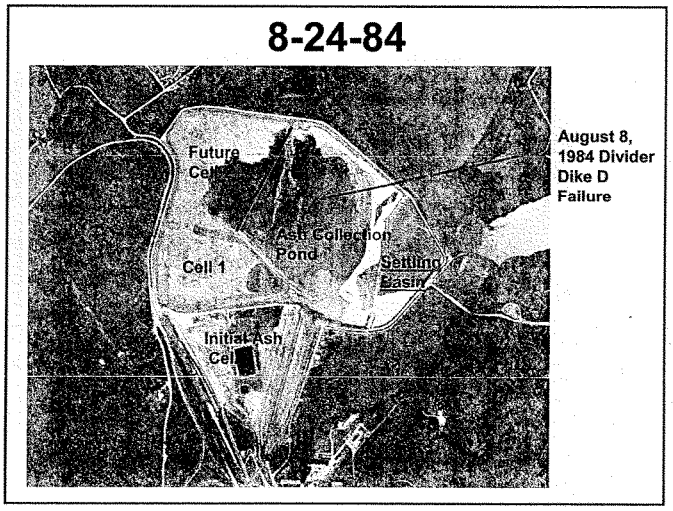

09-23-1949
Alignment
Emory
River
Swan Pond Watts Bar Reservoir

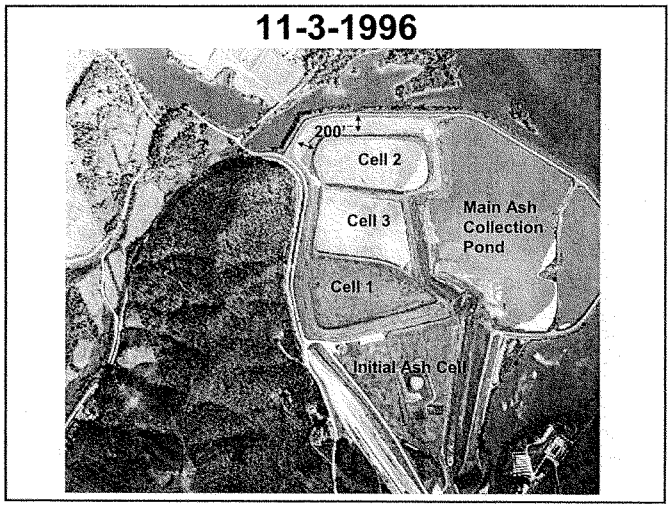

Plant Discharged Ash to Reservoir
Ball Field
After Filling
Prior to Dike C
No Closure
Open to Reservoir
1954 to 1958
WATTS BAR RESERVOIR
CONSTRUCTION PLANT AREA
PROJECT LAYOUT
GENERAL PLAN
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY

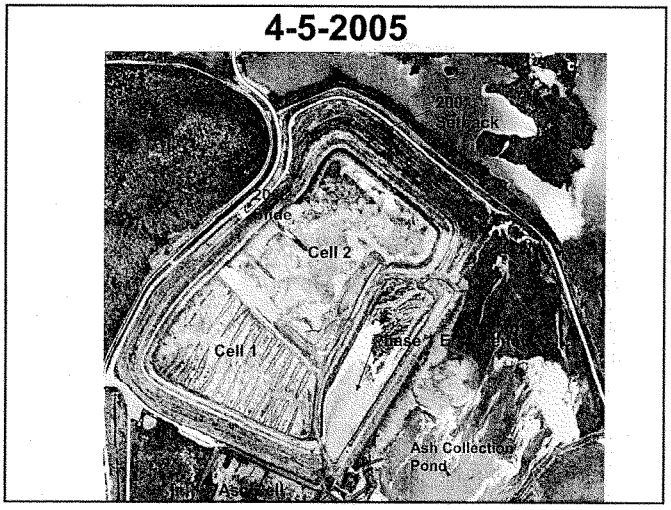

3-22-1959
Spillways
Small Particles
Dike C Complete 1958
Big particles
Delta
Initial Ash Cell
Intake Channel
Outlet


04-21-1962
Reservoir
Spillways
Ash Collection Pond
Delta
Initial Ash Pond
Intake Channel


1976
Spillways
Large
Delta
Ash Collection Pond
Initial Ash


8-24-84
Future
Cell
Ash Collection
Pond
Cell 1
Settling
Basin
Initial Ash
Cell
August 8,
1984 Divider
Dike D
Failure


11-3-1996
200'
Cell 2
Cell 3
Main Ash
Collection
Pond
Cell 1
Initial Ash Cell

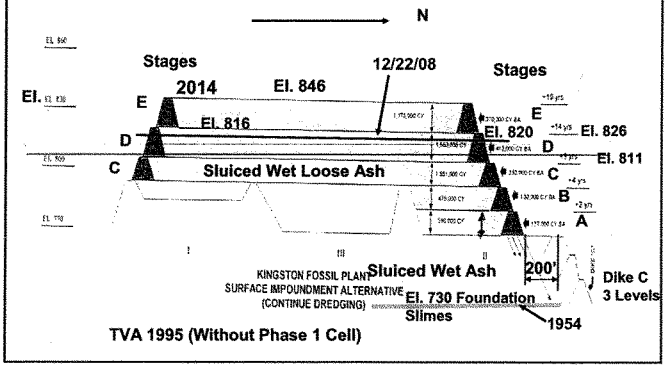

4-5-2005
200'
Setback
Cell 2
Cell 1
Ash Collection
Pond

Potential Failure Modes at Kingston Include:

1. Earthquake Instability
2. Excess Rainfall
3. Rapid Reservoir Drawdown
4. Karstic Limestone Sinkhole or Bedrock Instability
5. Artesian Groundwater Instability
6. Shallow Dike Instability Due to Seepage Outbreak or Piping
7. Intermediate Depth Instability of Dredge Cell or Dikes
8. Deep Seated Instability of Dredge Cell through Ash Only
9. Increased Filling Rates into Dredge Cells
10. Deep Seated Foundation Instability Under Dredge Cells
11. Consequential Undrained Failure of Ash Causing Flow Slide (Static Liquefaction)
12. Progressive Failure after Initial Cell Breach or Slope Instability

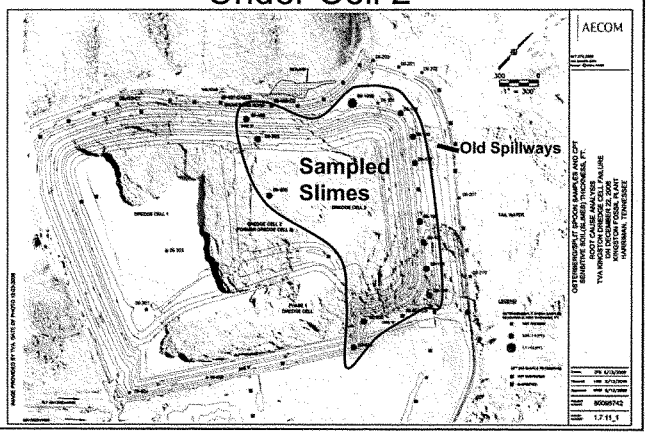
Key Failure Modes

Active Cell 2 Filling, Dike Containment, and Foundation Supporting Loose Wet Ash

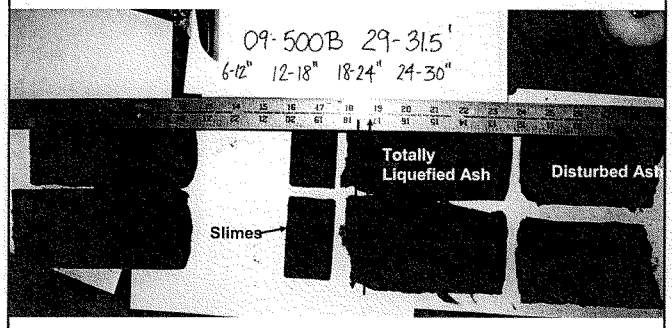


TVA 1995 (Without Phase 1 Cell)

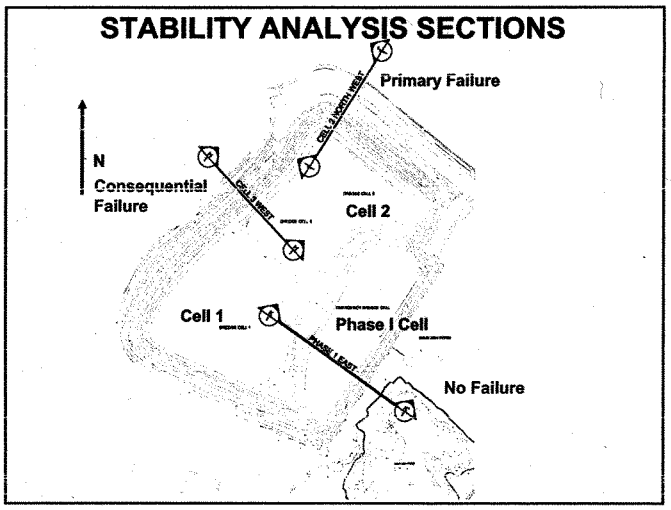
Location of Silt and Flyash Slimes Under Cell 2

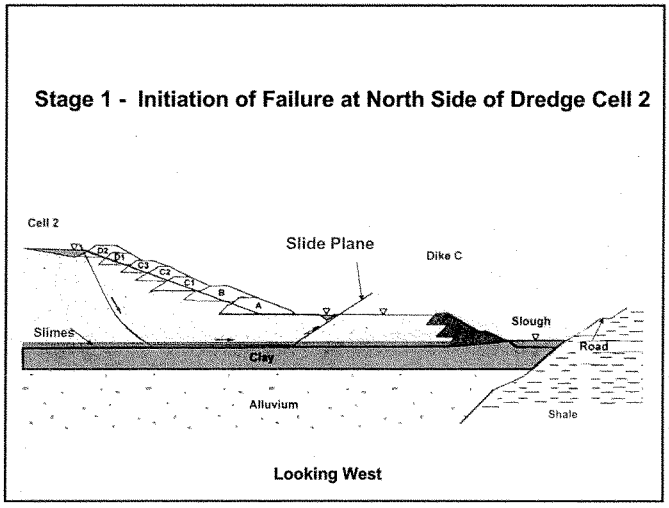


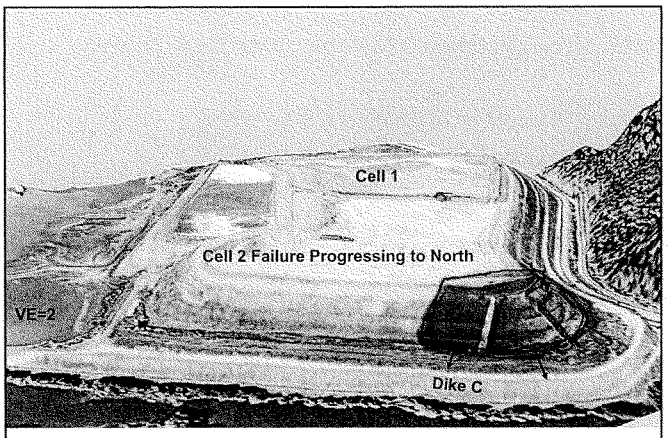
Clay/Laminated Slimes/Failed Ash at 09-500B, OST5



09-500B S5 29.0 to 31.5 ft

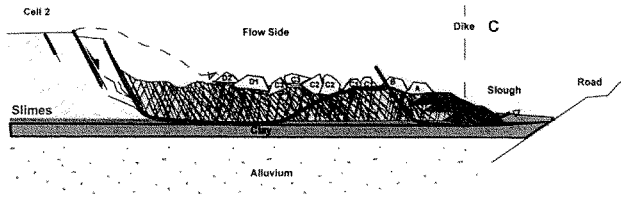

STABILITY ANALYSIS SECTIONS
Primary Failure
N
Consequential Failure
Cell 2
Cell 1
Phase I Cell
No Failure


Stage 1 - Initiation of Failure at North Side of Dredge Cell 2
Cell 2
Slide Plane
Dike C
Slimes
Clay
Slough
Road
Alluvium
Shale
Looking West

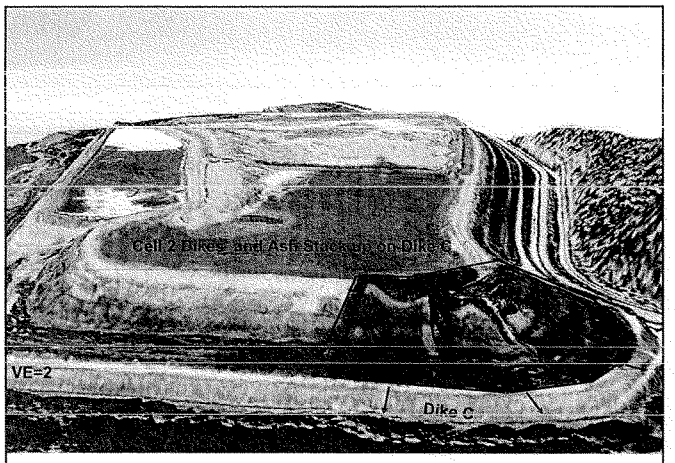


December 22, 2008 Expected Failure Mode at NW Corner of Cell 2

Stage 2 – Ash & Dikes A thru D2 Pile Up Against Dike C. This Surcharge and increased Ash Pressure Causes Dike C to Fail

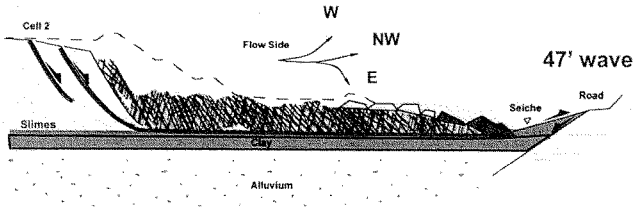


Looking West

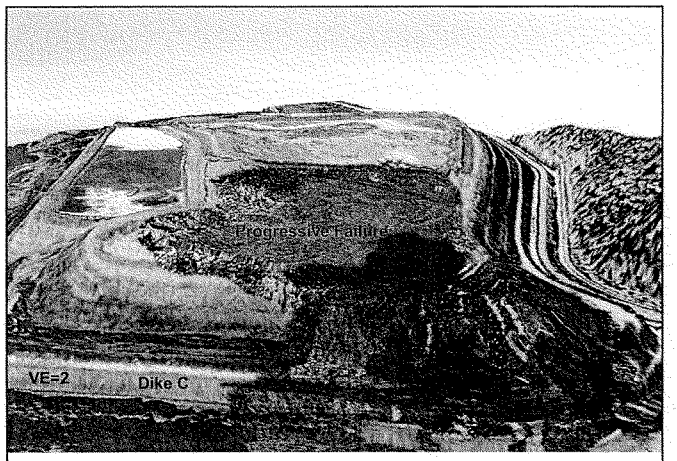


December 22, 2008 Expected Failure Mode at NW Corner of Cell 2

Stage 3 – Progressive Failure Southward that Fails North and West Dikes A thru D2 Back to Cell 1 Di Dike. 5.4 Million CY Fill Sloughs and Reservoir

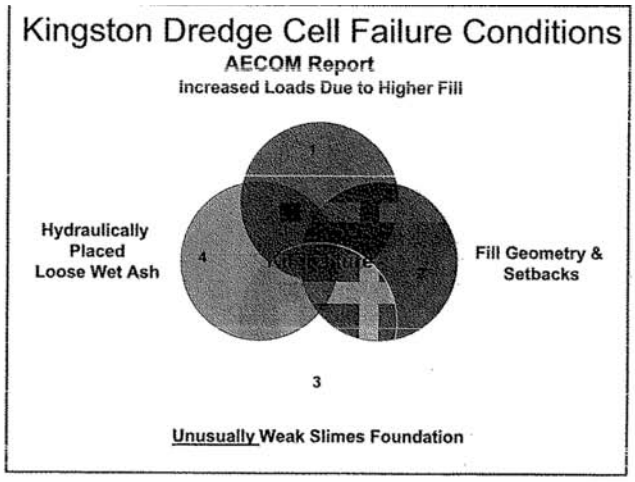


Looking West



December 22, 2008 Expected Failure Mode at NW Corner of Cell 2

December 23, 2008 Post Failure Photo Overlaid on TVA Surveys


Kingston Dredge Cell Failure Conditions
AECOM Report
Increased Loads Due to Higher Fill
1
Hydraulically Placed Loose Wet Ash
4
Failure Surface
2
Fill Geometry & Setbacks
3
Unusually Weak Slimes Foundation